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THE WATER WORKS PUMPING STATION[1]

BY ROBERT W. ANGUS[2]

One of the most important features of a water works system is the pumping plant, and it is often the part to which least attention is paid. If this plant has not been well selected and placed, one is not only confronted with a large expenditure for power and attendance, but may also suffer from lack of water, or from low pressure, at the critical moment.

Not so very many years ago the reciprocating pump was the only type used for this purpose, the source of power being either a steam engine or a hydraulic turbine, and a number of smaller stations are operating in this way yet. Some of the larger stations also use the reciprocating unit to a certain extent, and Toronto still has a large installation of them, although all have been in use for many years and are not new.

VERTICAL TRIPLE EXPANSION ENGINES

Milwaukee has very recently installed a number of vertical triple expansion units of large size, and these have shown very high efficiency, although when reduced to the same steam conditions, the results are identical with those on a similar unit in Toronto, tested by the author in 1906. The Toronto machine established a record for duty, exceeding 172 millions of foot pounds per 1000 pounds of

[1] Presented before the Canadian Section meeting, March 3, 1926.

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dry saturated steam at 150 pounds and showed a mechanical efficiency as between steam indicator diagrams and suction and delivery water pressures of 96 per cent. None of the other types of pumps have given anything like such good results since.

The smaller steam-driven reciprocal units are often very wasteful, due to leaky plungers, leaky valves, tight glands on the rods, etc., so that careless operation may bring their efficiency down below 50 per cent.

CENTRIFUGAL PUMPS

The centrifugal or turbine pump has very largely displaced the plunger type in all large steam-driven sizes, and lends itself to high speeds of rotation, making it suitable for direct steam turbine connection. The efficiency of these pumps has shown a very rapid increase and the duty of steam-driven units has risen about 50 per cent in the last twenty years. They are relatively low in cost, occupy a small space, require little attendance and upkeep and have a long life.

The adoption of centrifugal pumps in America has almost entirely come within about twenty years. Like all new machines they made very slow headway at first, as they were difficult to take apart and repair, their properties were not well understood, many of the earlier machines had very low efficiency, they did not give the required discharge, and had a short life. Some of the early purchasers had good reason to regret their action.

The pumps had so many advantages that builders quickly put them into a practical shape and to-day they virtually control the water works pumping field. The earlier units rarely gave efficiencies exceeding 70 per cent, while large pumps have recently been made with 86 per cent efficiency. One of the important developments has been the adoption of the single-stage pump for a wide range of conditions, and there is a tendency to-day to increase the speed sufficiently to make single-stage pumps serve for high heads.

SINGLE-STAGE PUMPS

The adoption of a single stage simplifies the mechanical construction and reduces the cost, and gets away from many balancing problems. Builders very largely omit the guide ring, so much in use at one time around the outside of the impeller. This is also an advantage to the purchaser, as the ring always gives some trouble from leakage, and its angles are only suited to a single discharge

condition, although the range of discharges actually varies greatly in the same pump.

The use of the horizontally split casing has done much to popularize these pumps, as they may now be examined internally with great ease, and further, the use of impellers which give very flat power curves has proven a good asset. Pumps are now very largely made with this characteristic, the maximum power for driving corresponding to the discharge for best efficiency, and on each side of this point the power falls off.

HIGH-SPEED LOW-HEAD PUMP

At the present time there is room for further development of the high speed, low-head pump, only one or two makes of such machines being on the market now. The author recently ran a test on a pump for about 18-foot head, driven by a motor at 250 r.p.m., proportions causing the designer some difficulty, although fortunately the capacity of the pump was large. A very much more compact unit could have been made had it been possible to run at say six times the speed, and it is likely that further development of machines to suit these low heads will be made. One such pump, with a screw-type impeller, is in the Hydraulic Laboratory of the University of Toronto, and gives the required head of 12 feet and discharge of six million Imp. gallons daily, at 1500 r.p.m., with very good efficiency.

STEAM TURBINES

Reciprocating steam engines have been very little used for driving centrifugal pumps, except through belting, because of the relatively low engine speed and relatively high pump speed. A very common drive now is the steam turbine, which is direct-connected, but the steam consumption on small turbines is excessive and they are, therefore, rarely used for the smaller units.

The standby losses on steam-driven units is very high, the coal used for banked fires being often more than that used for pumping where some auxiliary plant is available, and for these and other reasons, not necessary to discuss, steam stations are decreasing in Ontario.

ELECTRIC MOTORS

Electric motors are now one of the most common sources of power for pumping in Ontario, and they serve splendidly for direct con-

nection. One fault with them is that they are frequently too small for their work, and run too hot. This is largely due to the fact that the pump either exceeds its capacity at given pressure, or that it is low in efficiency, or else is running at too high a speed. The purchaser is frequently so pleased, in the first case, to get more than he is paying for, that he does not realize the load being put on the motor. Low efficiency is usually a cause for rejection, but the author has come across so many cases where speed much exceeded that stipulated, that he feels attention should be given to this matter.

It is not unusual to find a pump, purchased for a speed of 1750 r.p.m., running at 1800 r.p.m., due to electrical conditions and this results in an increase in demanded power of 9 per cent. If, in addition, the pump is high in capacity, it is clear that the motor will carry an undue overload. For these reasons, the motor should have an excess of 15 or 20 per cent of power over that expected for the pump.

Centrifugal pumps must be primed and are very sensitive to the presence of air in the suction, so if poorly set they may entirely lose their suction and run dry, causing considerable danger to seizure inside the pump, as it is ordinarily made. It is very desirable, therefore, to set the pumps as near as possible to the suction well, preferably so that they will be below the well level, and any gain that may be possible in the lowering of the pump is generally justifiable. A long suction pipe is also to be avoided.

STANDBY UNITS

For standby service, one of the most suitable pumping units is the direct connected centrifugal pump and internal combustion engine. So far gasoline has been largely used for fuel, since engines using it may be run at high speed, but heavier oils are also being used and adapted to such service, and are safer, cheaper in fuel costs and give no difficulty in operation. One unfortunate condition, all too common with such units, is that their setting sometimes causes them to be very noisy, and at times dangerous. Cases are not unknown where the hot exhaust pipe has set fire to the pump house.

Noisy operation can be avoided, and engineers would do well to realize that good work will not be done by the operator in a noisy pump house, and they should, therefore, deliberately plan to have a quiet unit.

Every pumping station should be equipped with a proper meter for the water as well as for the power supply. Such meters, now made by competitive companies, are remarkable in their accuracy, and enable the operator to keep a record of his output and efficiency, and every effort should be made to have this carefully done.

SPACE AND LIGHT REQUIRED

Most operators have ample time and facilities for keeping the stations and machines clean and free from rust and other objectionable matter. Polished surfaces should be kept bright and should not be painted, and the pump house should be designed with good light and plenty of space, and under such conditions the operator will usually take so much pleasure in his equipment that he will keep it in the best of condition.

DISCUSSION

W. L. McFaul: I have not found anything in Professor Angus' paper to which I can take exception. I am going to put in a standby pump for the Hamilton water works, but we have not as yet decided on the type of pump we will use.

R. H. Starr: I am going to stress this paper, and there are one or two things in relation to the pump house which we should stress. It is extremely important where a utility commission is operating the water works and electric utility, that the situation of the pumping house should receive considerable attention. Ten or twelve years ago we built a new pump house and put it in the residential section at one end of the town. Now they are worrying about the cost of changing the location of the station. With a little foresight we could have put the pumping station and the electric substation in one location near the centre of the town, not at one corner, and by doing that we could have avoided the expense of a long main and three operators.

There is one thing on which I do not quite agree with Professor Angus' paper, and that is in reference to having a motor with more capacity than the pump. I am doing this for the sake of you fellows who have to pay Hydro bills based on a 90 per cent power factor. If your motor is 200 h.p. and only called on to supply 175 h.p., then you are going to have a poorer power factor, and you will have to pay for it in your "thirteenth bill."

In connection with noise, we had a unit connected with a gasoline engine which unfortunately met with an accident due to the design of the engine. We now have a new unit which has a much steadier engine, although the same horse power. The exhaust pipe from the engine is carried about 60 feet in the waste-water pipe from our filter, and we get practically no noise from our exhaust. The only sign we have that the gasoline engine is running is the steam coming out where the waste water enters.

R. N. AUSTIN: It is difficult to say that high efficiency is high speed. Nobody seems to have been able to design a pump that will give high efficiency at high speed at, say, 2000 r.p.m. You can run a pump at 1750 r.p.m. and attain an efficiency of 78 or 79 per cent. The problem is large capacity and low head. At high speed it is not possible to attain efficiency. The hydraulic conditions are not good enough in the pump to get high efficiency.

J. P. MCRAE: One point that I would like to stress is that 95 per cent of our pump troubles are on the suction delivery of the pump. I do not think engineers pay sufficient attention to intake conditions. The lower the suction, the better the performance you are going to get.

W. S. LEA: There is one point in connection with steam standby plants. Where the coal used for banking is large in comparison with the coal used for running, it is well worth while considering the installation of equipment to permit working the boilers at high rating, either by the unit system, powdered fuel or by mechanical stokers. A paper was read at the Pulp and Paper Convention at Montreal by one of the representatives of the powdered-fuel equipment manufacturers in which he said that there are plants now in operation that successfully employ the unit system without any drying equipment whatever. That is to say, it is quite capable of satisfactorily handling the coal with the moisture content it usually contains as received from the mines.

In connection with the problem that is sometimes met in motor-driven equipment, arising out of high starting current and comparatively low power factor, I would point out that there is now available, probably at an advanced cost over the better-known types of motors, a so-called asynchronous-synchronous motor, which

combines the starting characteristics of a wound rotor motor with the running characteristic of a synchronous motor.

While high-speed pumps are desirable, it must not be forgotten that they are open to the objection that they are not so well suited for high suction lifts as moderate speed units.

E. V. BUCHANAN: In view of the great reliability of electric motors, some stations could be made automatic. I have in mind doing that with one or two of ours at the present time. It is only a matter of having floats in the station, and it will run by itself for twenty-four hours at a time with simply a day operator to clean up the station and see that the bearings are properly oiled and the pumps in shape. I am quite sure that is feasible. I think that the use of an operator in an electrically driven station is a matter of the continuity of our own practice.

I would like to stress again the point in Professor Angus' paper about long and high suctions of centrifugal pumps. There are places where we have centrifugal pumps and where we have met with trouble due to long and high suctions.

THE CHAIRMAN: There is no doubt but that this is getting to be the push-button age.

H. G. HUNTER: I think Professor Angus is to be congratulated on his paper. He has put forward a question that can be well gone into by pump manufacturers. My opinion is that the efficiency of a low-head pump up to 20-foot total lift is probably somewhere in the vicinity of 60 to 65 per cent. I doubt very much if the average pump is efficient over that. It seems to me that a pump could be designed to operate at a little higher speed and get better efficiency. There is no question in regard to the setting of the centrifugal pump if conditions make it convenient to get the pump as near the water as you can. If it is possible I would back-plug a centrifugal pump. On the other hand I would not hesitate at all to put a centrifugal pump as a low-head pump in with a suction lift limit of 16 feet. I have a great number of them operating under these conditions and I have never had any difficulty.

N. M. R. WILSON: Speaking in regard to Professor Angus' remark about standby charges on boilers. We have to keep up steam with

our regular plants, and our records show in several cases where we have actually used the steam pump for the whole day at less cost than banking the fires. I have been in favor of the crude-oil engine for a good many years as a standby unit. The unfortunate thing is that the first cost of a crude-oil outfit is very high. If the installation charges could be cut down to a reasonable figure, there is no question but that the crude-oil engine would come into very general use as standby for driving a generator for electrical current.

JAMES BAIN: We have several places that are running automatically, but I think that it would be difficult to run our pumping station automatically. We have three different steam plants, and that means three gangs of men. Our plant has been in operation since 1859.

In building a plant I think you should centralize as much under one roof as possible. You must keep your steam plant away from your electrical apparatus. We have had a lot of electrical interruption caused through line trouble. Our line has broken down three times. I had to call in the assistant operators as firemen. These men had never handled a shovel before in their lives. We had to run on steam power for a whole week. We were the first to use Hydro. We made our start December 24, 1910. When you get up against a break-down it is hard to work your apparatus automatically.

Speaking about the power factor, there is a motor available now that cuts down the cost considerably, and where you have a pumping plant you can keep your power factor down if you put in a number of small units.

If you have a high-speed pump it is hard on the suction. The minute you get high speed in the pump you have lower suction. You cannot get high speed and good suction at the same time.

WM. GORE: Speaking on the question of speeds of centrifugal pumps, they are really dependent upon three factors. First, the manufacturer has all the details and he can tell you what is best for the situation you have to meet. You have to take an article that has been developed by experience. Probably the manufacturer has spent a good deal of money in developing his pump.

The next factor is the power. The bills that we have to pay the Hydro-Electric Power Commission depend a good deal on the effi-

ciency of the pump we use. In fact I would say that an inefficient pump is dear as a gift. An efficient pump soon pays for itself in the saving in the cost of power. The Hydro Power Commission will come along and say, "You must have high-speed pumps." Why is that? They say if you have a low-speed pump the motor that drives it must have a large air gap, and they do not like that because the power factor of the motor is down. You must have a motor in which the rotor runs very close to the starter.

Then there is the question of finance. We all know that the higher the speed of the pump, the more the pump costs.

I believe in large pumps, the best efficiency seems to be obtained in the neighborhood of 50 pounds pressure. It seems as if two pumps in series is the solution. You must keep the speed of the pump up. We are forced into that by finance and by the Hydro Commission of Ontario.

With regard to the general question of pumping station design apart from the pumps: I think I laid my views on that point before this Association a year ago, and I can only reiterate the views I expressed at that time and say that I think a pumping station in order to get the best results should be worthy not only as to efficiency, but it should be something that a man in charge of it could almost worship. You should make it like a piece of artillery. A man will look after his guns because he loves them and because he can keep them clean and beautiful, and he will also keep them efficient.

I think that the pumping station should receive our most careful consideration. Last night I went to a moving picture show and I saw views of my old home district, and it gave me a sort of a home-sick feeling. They were views of old London. Something struck me while looking at these pictures that had not struck me when I was there, and it was the absence in the streets of extraneous matter like poles and wires and all sorts of things all over the place. If you look through our streets you will see all kinds of that impedimenta that should not be there. I think we should apply the same efficiency to our pumping stations. They should be free from impedimenta. If there must be pumps, they should be under the ground and out of the way. I think the pumping station is the palace of our water works system, and it demands most careful consideration.

N. M. R. Wilson: There is one point that has not been mentioned regard to the push-button system, and that is the underwriters.

You cannot have your pumping house run automatically without getting your fire insurance rates up. The fire underwriters will insist on having the station manned by operators who will be always there.

E. V. BUCHANAN: I was referring to an electrically-driven station and I spoke of automatic control. If the pumps stop in such a station, the presence of an operator will not bring them on again. The station can be made to work automatically just the same as if the operator were there.

W. L. MCFAUL: We have an old pair of engines that were installed in 1859 and for sentimental reasons they are still kept in use as a break-down service. We were having a fire test on the market, and I do not know what put it into my head, but I put these engines on the first thing in the morning and I ran them through the test.

KEEPING THE WATER WORKS WORKING[1]

By C. R. Henderson[2]

I have been asked to write a non-technical paper which will in some way impress you with the importance of the service in which we are engaged and will also suggest some of the difficulties which have to be overcome in order that water service may be safe and uninterrupted.

While the business of water supply is important, it is not spectacular. No utility renders a more essential service and none has greater responsibility than the water utility. The people are dependent upon transportation, communication, light and power for their well-being and you often hear of the splendid contributions on the part of these utilities to comfort and public welfare.

The railroads transport food, raw material, finished products and passengers, but we are learning that there are many substitutes for railway transportation. If the telegraph or telephone lines go down and the mail service stops there are other ways of getting communication through. If the light goes out we can at least get the kerosene lamp out of the attic or borrow some candles. Likewise there are many substitutes for electric power.

Serious as interruptions suggested above may be, we doubt if any interrupted service is quite so serious as the interruption of water service in modern cities. There is no substitute for water and few substitutes for the service rendered by the water utility in urban communities.

Fortunately, no service is more reliable.

The distribution of water is not much affected by storms—earthquakes, perhaps—but wind and weather have little to do with cast iron pipe laid six feet under ground. Labor troubles and strikes do not reach us, our property is safe from fire (or ought to be) and we usually have a source of supply ample in quantity.

What then are the troubles of the water works man and what must he do to meet them?

[1] Presented before the Iowa Section meeting, December 2, 1925.

[2] General Manager, Davenport Water Co., Davenport, Iowa.

Perhaps the most serious difficulty is in maintaining the purity of the supply. Surface waters are becoming more and more polluted by sewage because of public indifference and official neglect. These waters, if used for water supply, must be carefully purified and closely watched for changes in character which sometimes occur suddenly and which require prompt treatment. Nearly all surface waters now require treatment, but so called "pure supplies" may be as dangerous as, or even more dangerous than, impure supplies if suddenly polluted when we may not be on guard.

Dangerously polluted water is usually followed by sickness and sometimes by death, and because other agencies are too slow to detect occasional impurities in the water supply, the operator of a water works must know day by day, and hour by hour, that his supply is safe.

History is full of cases in which uncounted losses have followed the sudden washing of sewage into a stream or lake, thereby causing an overload to the protection of a surface water supply, and there are many cases of the contamination of so called "safe waters" after they have been brought to the surface of the ground.

Our numerous duties sometimes conflict, one with another.

In the middle of the night a conflagration starts in the midst of valuable property. The water works is required to furnish, perhaps, five or ten times the quantity of water being pumped at the moment. It is not always easy, and it is sometimes impossible, to make all the delicate adjustments necessary to remove bacteria as efficiently in emergency as under normal operation, but the water man is supposed to do it.

The fire department puts out fires but a fireman cannot go far without a good supply of water to back him up, so we are advised to provide large mains to supply a number of hydrants simultaneously, in addition to other domestic demands, which may be heavy or light when the fire starts.

We are also advised to provide extra boilers and extra pumps and other expensive equipment for use in fire extinguishment.

Other supervisors set up standards of drinking water which require more and better devices for purification and much skilled supervision. In other words, the fire protection engineer is constantly improving the standard of fire protection and the requirements to be met by water works, and the public health man is constantly revising and raising the standard of quality. Both duties are important so it is

up to the operator to find a way to ride both horses at the same time.

The municipal engineer on the other hand is paving streets, installing conduits and other structures under the streets, thereby making it more and more expensive to install and maintain water works.

The sanitary engineer is increasing the spread of sanitary sewers and, in many cases, adding to the load of pollution that the water works man must extract from the water supply.

But we have yet to hear of the man who is striving to increase the revenue of the water works in order to make it possible to do the very much worth while things above referred to; this burden is placed on the water works man and he is suspected of selfishness as soon as he asks for more money.

Circumstances beyond our control have about doubled the cost of our service in the last ten years.

Many reports of public officials come to my desk in the course of a year and I am impressed by the number of warnings contained in these reports that apparently make no impression on the persons addressed. Reports of inadequacy, danger of interruption in supply, danger of damage to public health. I sometimes find the same complaint in several annual reports from the same city, so it is evident that no attention is paid to the warning, or, if so, nothing is effectively done.

As an example, the following is quoted from the report of an eastern city. "In a series of dry years our supply should, theoretically, furnish our present consumption. Unfortunately, however, our greatest reserves are in Westminster and the capacity of the present pipe line to the city is only about one half the daily consumption."

Why do we find these conditions so often? Probably because the public is indifferent or because of lack of funds. There should be no lack of funds to provide adequate and safe water supplies. The difference in costs between supplies inadequate and unsafe and those safe and adequate is not usually great, and nothing is more important than a safe water supply.

I think the water superintendent has more to complain about in the lack of public support of what he knows to be safe policies than he has in any other or more personal matters.

The water man has a fine opportunity to render steady service, day and night, to the people dependent upon him. He usually has a

pride in his job whether it be a big job or a little job. He knows too what Thomas R. Marshall said "He who serves the people would better serve with the understanding that the only reward he will ever get is his consciousness of having done his duty."

"Governments are ungrateful and speedily forget the sacrifices of their citizens," but for all that I believe "he profits most who serves best" and the consciousness of having done one's duty is a very considerable reward.

No profits are now probable in the water works business in connection with poor service.

Too many agencies of publicity are engaged in showing up the service rendered by the water man. Parties of experts come to probe into all the dark corners of what you might consider your private affairs and they publish to the world all your delinquencies and shortcomings and apply a scientific system of points of deficiency to what you have so proudly accomplished.

Again—if you have certain industries in your city the United States Department of Agriculture checks up your work in water purification. If a train or ferry boat taking water from your mains crosses a state line the United States Treasury Department has a standard for you to live up to. If you have a public hospital the hospital service checks you up and, also, the daily and weekly reports of your operations are welcome at the office of the State Board of Health. So it is "watch your step" if you would continue stepping Mr. Water Works Man.

However, if some manufacturer pours oil or discharges tons of organic matter into the river or if a municipality puts raw sewage into the water there are not so many agencies to caution them. In fact, I rather think they are within their rights because it is probable that your home town also contributes to the pollution—downstream of course—and not having "clean hands" cannot complain of its neighbors up stream.

In order that this paper may have a wider viewpoint, and, also, in order that it may reflect the experience of the water works men of this section, each member was asked to contribute some item of experience to illustrate what it means to keep the water works working. This paper would be too long if all the material received were included.

One superintendent writes that on a recent occasion an accident occurred at the pumping station requiring him to call in all the mechanics he could muster from the trades, to make repairs and to

work without stopping for forty hours before a temporary supply could be secured. He said that if a fire had occurred during the forty hours it would have been disastrous.

Another case reported involved a fire in a leading hotel, early in the morning when the temperature was 18 degrees below zero. Before enough water could be secured to control the fire the superintendent had to shut off the water mains supplying other parts of the town, thus concentrating all the water the wells, and the reservoir supply, would furnish, at the location of the fire. The result in this case was to create public sentiment for better equipment and so the bad conditions were remedied later on.

Another report covered a collision between a Ford and a fire hydrant. There was nothing strange about this for it occurs every day, but in this town the valves were covered with 6 inches of ice and were inaccessible for prompt use, so in order to stop the flow of water the pumps were shut down, the Ford removed and the hydrant plugged; but by this time the superintendent and his men were walking icebergs.

Within the past thirty days one of the principal mains in Davenport was found to have a crack in it. It was a 24-inch, Class C, cast iron pipe. As soon as the crack was discovered the main was shut off and the work of replacing the pipe begun. Service was maintained through other, parallel, mains but every water works man knows there was no delay in getting the principal main back into service. The men worked all day Friday and all day Saturday and part of Sunday, and if you attended a football game in Iowa on Saturday, November 7th you know the blizzard they had to work in. Every moment the superintendent and his men were doing all that could be done under such adverse circumstances. Did the public know what was being done for them? Of course not. No one knows but ourselves. No publicity would result unless we failed to do our job and the service was interrupted in consequence thereof.

In the city which is now our host, at 5 o'clock in the morning, a 20-inch plug blew out of a cross in the main feeder line between the pumping station and the reservoir. The pressure at the station dropped from 95 to 35 pounds. Within an hour the district for a distance of three blocks, which included the leak had been shut off and the pressure restored to normal. The public knew nothing of the accident until they read the account in the evening papers. The speed with which this shut off was accomplished was due to the acces-

sibility and good working order of the valves and the familiarity of the crew with their location.

Another close call in the same city occurred when the water department was making a new cross connection within three blocks of the Orphans Home. Fire broke out in the institution while the water mains were shut off and while several hundred children were in the buildings. There was, of course, no water in the hydrants to control the fire but by quick work and quick thinking several valves were manipulated and a double line of hose laid as a by-pass around the open main, connecting from a live hydrant to an empty one and supplying water to hydrants several blocks beyond to control the fire. The buildings were saved.

The following comment was received from one of the largest cities in our section.

> The water department operates as a unit of the fire department in case of second and third alarm fires or other serious emergency. Day or night, winter or summer, the superintendent and general foreman respond to these alarms under the same conditions as fire officers.
>
> Repair gangs and special equipment such as hydrant thawing steamers, oxyacetelene cutting apparatus, trucks and tools are ordered to the site of the emergency to handle not any trouble that might develop in connection with the water supply, but to assist in any other way that the senior officer of the fire department may request. On one occasion these men remained on duty at the scene of a serious fire, with the temperature below zero, for ninety-six hours with only such rest as could be obtained in nearby stores.

The dean of water works men, Wm. Molis of Muscatine, reports that:

> In the early days when Muscatine obtained its water supply from the Mississippi River the pumps began to act badly one afternoon. A sand bar had covered the intake 700 feet from the shore. Water from the elevated storage reservoir was discharged backwards through the intake to dislodge the sand, but without success, when fire broke out one block from the pumping station. Eight streams of water were required for the fire and service was maintained through the use of a suction pipe to the shore line kept open by men in the well. The next day a dredge was employed to remove the sand and the public knew nothing about it except that the water was a trifle muddy.

Another serious incident occurred in the same pump well when a man who was sent down to do some work reported a dead body in the well. After telling the man *not to say a word* Mr. Molis says

> I got on rubber boots and old clothes to investigate the trouble. Going down in the well I found two large cat fish weighing about 200 pounds. I called to the

men to get the derrick ready with ropes and tackle to hoist the body. When I myself came up I was surprised to see the Coronor, the Sheriff and police, besides 1000 people, waiting to see what was supposed to be a dead body.

Hannibal, a charter member of this Association, reports

A few days ago we noticed an unsatisfactory condition in the filter effluent which could not be readily explained. The settled water turbidity was fairly low, about 100 p.p.m., coagulation was excellent, the filter beds seemed to be in fine shape, yet it was almost impossible to obtain a clear effluent. As the days went by our condition became more aggravated. The filter runs grew decidedly short in spite of frequent washings and increased dose of alum, and the effluent became more turbid.

The color of the water was normal for the Mississippi river at this location and microscopic organisms, chiefly Melosira, were not excessive. As a last resort we riged up a chlorinator and applied chlorine gas at the point of application of our coagulant, to the extent of 6 pounds per million gallons, when our trouble vanished like a cloud.

The following interesting reply was received from one of my neighbors, W. J. Schneider, General Manager, Bettendorf Water Company:

As you know we are also connected with the Bettendorf Light and Power Company. Comparing the two services—water and electricity—so far as grief of the service is concerned, it is a whole lot easier to deal with the public on the subject of electricity than it is on the subject of water. The average man will kick on a $1.00 monthly water bill but he will never say a word on a $2.00 light bill. Electricity is easy to buy, easy to meter, and easy to deliver. Water you have to manufacture yourself, it is hard to meter accurately and is expensive to deliver. Our water investment is six times our electric investment but our gross receipts on water are only one-half of the electric gross receipts. In our water plant on our present scale of rates we turn our capital once in fifteen years. In our electric company we turn our capital every three years. . . . . A peculiar condition exists in that we have never found a single person who wilfully stole water from us. Stealing electricity is quite a common occurrence."

Perhaps the greatest handicap a private water company has to overcome is the quite general belief held by the public that the sole and only object of the company is the making of money.

Of course, the company hopes to make some money. Any sort of good service would be difficult, if the business were running at a loss. But did you ever stop to think that it is perfectly proper for a utility to make a reasonable profit? It is not even bad morals. Of course, you don't want them to take it all—but there's no danger. Very

few water companies take in as gross revenue more than 12 per cent or 14 per cent of the actual value of their property and most of them have a gross revenue of not more than 10 per cent. Operating expenses, maintenance expense and taxes have to be taken out of that before there is anything for bond interest, dividends, depreciation or surplus.

I know of more than one water company that pays one-sixth of its gross income for taxes alone.

It may surprise you to know that almost no other large business could survive on the meager earnings of a water company. It may be that water companies may not continue to be an exception, but it has been done because of the safety of the investment and its absolute necessity as a service for which there is no substitute.

If I were to ask a boon of the public it would be that it treat its public utilities as a good employer treats his private servants and employees. Dealing out censure when careless or indifferent service is rendered, penalties, perhaps, for serious lapses, but commendation, encouragement and reward for good service. I believe that recognition of a sincere and intelligent effort to serve would result in much more of this kind of service.

FINANCIAL REPORTS OF WATER WORKS OPERATION[1]

By H. F. Blomquist[2]

The success or failure of a service utility is measured in two dimensions: the quality of service it furnishes, and the cost of the service given, whether it is low, moderate, or excessive. A public water works furnishes three distinct kinds of services at a certain cost to those who receive them. This paper will deal with the cost side of water works operation, and will treat the subject from the viewpoint of municipal operations.

Students of government have recently stressed more and more the importance of the budget system in expenditures of public money, and have recommended this method as especially important in municipal affairs. The principle of the budget system is to determine before hand the amount of money to be expended for a particular activity of the government, raise the amount for that particular purpose, and use it for no other. We must concede that this is the most business-like way of conducting public business.

When a municipality undertakes the operation of a water works it enters a field of service that can also be furnished, and in many instances is furnished by a private corporation under its own management, subject only to certain governmental regulations, necessary on account of the monopolistic nature of the business and its uses of public streets and other privileges in a community. Public ownership of water works has become popular because water service is so closely connected with the public welfare, especially in its relationship to fire protection, street cleaning, sewer operation and other public uses.

In harmony with the principle that each activity of a municipality should be maintained by money set aside for that particular purpose, the finances of a municipally owned water works should be kept entirely separate from other funds and be used only for the promotion and operation thereof. This is further emphasized by the

[1] Presented before the Iowa Section meeting, December 3, 1925.

[2] Superintendent, Water Works, Cedar Rapids, Iowa.

fact that the water works is performing a function that can also be performed by a private party, which would have to provide its capital and receive remuneration for all services given. Since the sole function of a water works is to furnish certain tangible services, the total cost of operating and maintaining it should be derived from those who receive them, and each of them should bear his proportional share of the cost. In other words, a municipal water works should be operated as an independent department and be self-sustaining no matter how its capital investments were first provided. If they were provided by taxation, the water department should be debited by the municipality to the full amount and subsequent interest charges until the same is repaid or balanced by credits for public services given to the municipality, and should be credited with all public services such as water used for street and sewer flushing, parks, fountains, and for its share in fire protection. The water work's books should show its full indebtedness, and carry that indebtedness until paid from its own earnings or credits.

All business enterprises must maintain a system of accounting best suited to their own needs, one of the purposes of which is to reveal at any time its financial condition. In order to make a correct statement of the financial condition of a water works, its system of accounting must take into consideration all items that belong to its invested capital, interest and all outstanding obligations, a sinking fund or other method of amortizing its obligations in amounts at least as large as its depreciation and loss of value on account of obsolescence or other causes. It should also account for the actual value of all services given, whether paid for in a direct way or not. Only when all these items are properly accounted for can a correct statement be made of the financial condition.

In addition to the financial accounting, and of equal importance, is a proper system of operating records. Record keeping in detail of the various operations of the plant are important not only for the historical information, but also for studying the performances of its various units. A certain machine, for instance, may be far from worn out, but, if its efficiency is so low that the difference in cost of operating it and one of a newer type with higher efficiency, is more than the interest on the cost of a new machine, it is economy to scrap the old one, even though it could continue for a long time to do the required work. The public, as owners of a water plant, often know very little about the condition of their industry, whether its

operation is successful from a financial standpoint or not. Their only means of finding out is from the quarterly or annual reports issued. These reports should, therefore, be so arranged that they will present in concise form the results of the plant's operation for the period covered, including all proper overhead and depreciation charges and all proper credits, and also give a general statement of the financial history of the plant. In addition, summaries of operating data for previous years are valuable for comparison as well as from a purely historical standpoint.

This paper is not intended to present any definite system of accounting, but to call attention to some sound principles very often omitted in reports of municipally owned plant. Many plants have been purchased or built with proceeds from bond issues or other indebtedness assumed by the municipality and later partly amortized by general taxation, mainly because fire protection was the first object sought. Later, as the water services were extended, it was often a mere matter of getting funds in one way or another to balance the expenditures, and still later, when earnings have exceeded the expenditures, the surplus money has been transferred to some other fund of the city. In such instances, a true cost accounting has not been made of the operation of the utility. Such methods do not promote efficiency and do not show its owners the actual cost of the services they receive. The services from any undertaking must be worth the cost; otherwise, the undertaking is a failure and should not be attempted.

Public water services are generally cheaper than any other commodity when their full values are considered, and are well worth their costs. If the plant and its accounts are given fair treatment, the results will be fully justified.

THE MENACE OF CROSS-CONNECTIONS IN A PUBLIC WATER SUPPLY[1]

By R. F. Goudey[2]

A cross-connection is a physical arrangement between a public water supply and a secondary water system, usually privately owned, whereby a flow of water into the public water system is possible. Such secondary supplies are scattered over the state by the hundreds and are to be found at most industries using moderate volumes of water or at buildings requiring the best of fire protection.

The private companies install cross-connections for their own convenience and for economical interests with little or no consideration for any necessary or reasonable precautions for the protection of public health. The seriousness and extent of this problem is little realized and the evidence, though considered most favorably from the private company's standpoint, nevertheless points to the inevitable conclusion that cross-connections between private and public supplies should no longer be tolerated.

Dual supplies have a legitimate use, but only when they are safely separated. Private interests forward many reasons for interconnecting supplies among which are:

1. Insurance rates for buildings or industries can be cut one-third to one-half if a duplicate water supply is provided, incidentally safeguarding life and property and insuring continuance of employment. The connected supplies in this case are usually separated by check valves or gate valves where other means of separation are not provided.

2. Large sums of money can be saved by industries substituting a cheaper and inferior water for the public supply for their processes which can be adapted to such water, while reliance for domestic, boiler and emergency use is placed upon the public water supply. Often in this case the two supplies are separated by a main check valve and a number of gate valve connections between the two systems at other points.

[1] Presented before the California Section meeting, October 6, 1924.

[2] Resident Engineer, State Board of Health, Los Angeles, Calif.

3. Some industries require a softer water, or water better adapted in other ways to their industrial processes than can be provided for by the public system. Connection with the public supply in this case is made for emergency use and is controlled by gate valves.

4. Great economy in swimming pools can be effected by equipping them for recirculation and purification, relying on the public supply for water for drinking purposes, showers, washing of filters, and periodic filling of the pool. Often only valves between the two systems are provided.

5. Some industries, when operating below normal, find it more convenient to temporarily turn on the public supply instead of starting up their private pumps. In this case nothing other than gate valves separates the two supplies.

6. It is advantageous to fill the salt water fire systems with fresh water after each fire to prevent excessive corrosion. This is occasioned by bypassing water around the check valve with a gate valve connection.

7. In many cases private pumps can more easily be primed from city water pressure by merely opening a valve.

The argument is not to negate any of these advantages, but to insist that they be gained at no sacrifice to public health. One would think this a fact too elementary to be mentioned, but it is one that has been ignored by waterworks officials, engineers for private companies and health officers. Instead of spending the necessary sums to separate properly the two systems the private companies usually install the easiest, cheapest and most direct means of connecting them. Herein lies the principal danger.

Any intent to correct the present practice in this matter, to say nothing of eliminating existing incorrect installations, will be met with strong opposition from private companies, insurance agencies and passive resistance from most waterworks officials. The California State Board of Health has passed drastic resolutions regarding cross-connections, but it will take a strong educational campaign and a determined stand on the part of health officials to eliminate the existing menace. One author states that, if the public knew of the dangers they are exposed to, they would rise up in arms against further use of cross-connections. It is well, therefore, to clearly state the factors indicating the seriousness of the menace of cross-connections in a public water system.

MENACE FACTORS

With the increased cost of water from public systems contrasted with the growing competition of private companies necessitating their development of cheaper sources of supply, and with the phenomenal success of automatic fire sprinkling systems, the number of new cross-connections is increasing faster than the normal development of new industries.

Cross-connections are never made twice alike—some are in conjunction with equalizing tanks, others are connected direct to the private distributing system, often they are buried in the boiler room or are scattered through the yards or buildings. Combinations of check valves, gate valves, and intermingling of the two systems are steadily becoming more complicated and intricate, as new uses for making such cross-connections continue to develop.

The controlling factor is pressure, which, during critical periods, if not at all times, is higher on the side of the private water system. False reliance is often placed on private systems supposedly having less pressure than the city supply, for, during periods of maximum use in a public supply or during its repair, the pressure on the private system invariably exceeds that of the public system. Many industrial plants install fire pumps in their private water systems to increase pressure during fires. Such pumps are "tested out" several hours a week, during which periods the pressure always exceeds that of the public water system. In some installations fire pumps discharge directly into the private distribution system without any equalizing tank, in which case the pressure may be built up much higher than the public water system. Generally speaking, in all cross-connections the pressures on both private and public systems vary hourly, sometimes being greater on one, sometimes on the other. Water will flow in enormous volumes through the slightest opening into the public supply, if the direction of the differential pressure is toward the public system.

The secondary source of supply is invariably polluted. From the very nature of its development it has to be a cheap supply and from the nearest body of water available, whether it be ocean, harbor, lake, pond, lagoon, slough or well. Obviously no consideration can be given to location of sewer outlets, bacterial quality, protection against pollution, mineralization or appearance. Most of the private companies warn their employees not to use the private system for

domestic purposes, for the courts hold that where pollution of the secondary supply is common knowledge the private company can not be held accountable for damages. In some cases the private water supply is safe, but from aesthetic standpoints it is still objectionable from its saltiness, turbidity, difference in temperature, or mineral content, to permit it to gain entrance into the public distribution system.

Since the secondary supplies are usually polluted and difference in pressure at critical times tends to cause a flow of water into the public system, actual pollution results almost inevitably, since all devices attempting to separate two supplies directly connected are positively unreliable. Such devices as have been installed include single or double check valves, gate valves, or a combination of gate valves and check valves.

A check valve is an enlargement in the pipe line where a clapper is hung on the inside near the top and which opens or closes on an opening in the main line as the pressure from either side acts upon it. The earliest of such valves were constructed entirely of cast iron, with the inside rough and cramped, easily permitting the clapper to catch on the burrs on the side or top or be jammed. This type of valve was universally condemned. The modern check valve is an outgrowth of the former cast iron valve in which all the moving parts are made of bronze with supposedly ample clearances and a clapper faced with hard rubber seating on a bronze disc of ample width to prevent injury to the rubber. Check valves leak on the slightest provocation, a fact well known by waterworks officials. Leakage in some instances has been recorded up to 200 gallons per minute. In one case a check valve passed a sufficient volume of water to throw a fire stream across the street. A city engineer in Massachusetts on examining some check valves found one fixed at 45 degrees with evidence of not having moved for several years. Meter readers in several instances have recorded backward reading of meters, indicating a seepage back through check valves. To think that mechanical perfections will prevent leaking of check valves in the public and private water systems as they exist today is absurd and illogical. As long as either supply contains substances which will lodge or accumulate under the clapper, such as pieces of sticks, sand, gravel, mud, clumps of moss, or fish, the proper action of all types of check valves will be interfered with.

The National Board of Fire Underwriters, realizing the complete-

ness of the evidence against single check valves, made recommendations sixteen years ago for installations calling for two check valves with means for testing tightness of both valves periodically. In a report of one of the inspectors of the National Board of Fire Underwriters sixty-one installations were found leaking in one valve and six in both check valves. One water superintendent in the east, after sixteen years experience with twelve sets of duplicate check valves inspected weekly, writes that they "need eternal vigilance, do leak on the slightest provocation, both are found leaking at the same time, and there is no assurance of tightness after test." The insurance companies have now gone a step farther by recommending installation of alarm devices to give warning when leaks occur. Undoubtedly such devices are a great improvement over the original check valves, but of what avail is this mechanical perfection since it does not hit at the real difficulties in the problem?

Enclosed devices in general are never reliable. If one valve can leak, so can two in succession; and if not conscientiously watched, are twice as bad as one valve. Double check valves are at best poor contrivances and tend to give a greater feeling of safety than is warranted by the facts. Until the personal element, insuring positive operation of such valves is cared for and until the water in both systems is filtered by conservatively designed treatment works, polluted supplies under no circumstances should be connected to a public supply through check valves.

In other cases the two supplies are separated by gate valves, some being adjusted daily either to prime pumps or for temporary use of water and others being more or less permanently closed or forgotten. In the first instance danger comes from failure to close valves tightly each time or to close them before water from the private system can gain entrance into the public system, if the pressure from the private side is suddenly increased. In the second case the valves may be so aged that they commence to leak. In either case the valves may be tampered with by ignorant or over-zealous employees. Valves have been put under lock and key, but this has not eliminated the danger from the personal element. It is evident that cross-connections, through gate valves are more pernicious than through check valves.

The greatest dangers, after all, are: first, the lack of appreciation among waterworks men and engineers of private companies of the extent and seriousness of this menace; second, the failure of health officers to understand problems involving engineering and mechanics;

and, third, lack of supervision from outside agencies to ferret out such connections.

EPIDEMICS RESULTING FROM CROSS-CONNECTIONS

That this discussion is not academic or theortical is borne out by many serious typhoid epidemics which have been traced directly to cross-connections as just discussed. The most notorious epidemic occurred in 1903 at Lowell, Massachusetts. Owing to failure of one or more check valves to hold during a period when fire pumps operated on a fire protection system owned by the Locks and Canal Company sufficient polluted water was pumped into the public distribution system to cause 196 authentic cases of typhoid fever and 16 deaths. Another important epidemic occurred in Van Wert, Ohio, in 1913. Here a polluted private supply in the Cincinnati-Northern railroad shops gained access to the public water system, the pressure of which suddenly dropped, causing 600 cases of sickness, 25 cases of typhoid fever and 2 deaths. A rather extensive investigation was made in Philadelphia in 1913, during which time 72 per cent of the cases of typhoid fever at Philadelphia were estimated as having originated from a series of faulty cross-connections in the industrial district. In Circleville, Ohio, in 1914 polluted water from the private supply of a strawboard factory leaked through two gate valves and two check valves and polluted the public water system, causing 43 cases of typhoid fever and 2 deaths. Elgin, Illinois, in 1916 had a rather large epidemic, in a watch factory resulting in 18 deaths. In Franklin, New Jersey, in 1922 leakage from a private water system at the New Jersey Zinc Mines leaked past a 3-inch check valve causing an epidemic of 140 cases of illness, resulting in some typhoid. The most recent epidemic occurred at Everett, Washington, in July, 1923. A polluted water supply from the Eclipse Mill gained entrance to the public distribution system through an open 6-inch gate valve ignorantly installed by waterworks officials and which became dangerous when the city pressure dropped below normal, causing 2000 cases of diarrhea, 77 cases of typhoid fever and 11 deaths. Serious authentic epidemics have occurred at Akron and Springfield, Ohio; Toronto, Ontario; Rockaway, New Jersey; Bloomington, Illinois; Milwaukee, Wisconsin; St. Paul, Minnesota; Mannington, Nitro and Piedmont, West Virginia; Watervliet, Ithaca, Newburg, Herkimer and Saugerties, New York; and Hoosac Falls, Massachusetts. The number of minor and un-

recorded epidemics occurring in the ten states above mentioned, to say nothing of the remaining states where publicity is never given to these matters would without doubt, if discovered, show even a greater extent of this menace than is recognized.

Records show that there have been at least 2000 authentic cases of typhoid fever directly traceable to faulty cross-connections and over 100 deaths. This represents an actual cost of over three-and-a-half million dollars with the actual loss of many times this amount. The menace from cross-connections is expressed in terms of million of dollars.

Many cases are on record where the public system has been supplanted by water from a private water system, greatly impairing its use for domestic purposes, but fortunately resulting in no disease.

At Rochester, New York, a gate valve at a lift bridge operated by two supplies was opened by an ignorant employee and a large portion of the distribution system was filled with objectionable water before its discovery. In New Bedford, Massachusetts, in 1903 a woolen mill pumped so much salt water into the distribution system through a check valve that it put the fire steam boilers out of operation. At the California Cotton Mills at Oakland, California, in 1917 a large volume of salt water was pumped into the distribution system through a 6-inch leaking check valve, affecting a large area in Alameda and Oakland. At Pinole, California, a dangerous and dirty, but chlorinated, water was pumped into the distribution system, but was discovered before any serious consequences resulted. At San Pedro, California, several instances have occurred where canneries pumped salt water back through gate valves accidentally left open, until citizens complained of saltiness in the drinking water. Only last month an epidemic of twelve cases of typhoid occurred in the Southern Pacific yards, Sacramento, from use of a polluted, but supposedly treated, secondary supply. A cross-connection existed with the municipal water system, but the epidemic was confined to the yards.

The menaces from cross-connections in public water supplies are briefly:

1. The number and character of new cross-connections is on the increase.

2. Secondary supplies, since they are developed principally for economical considerations, are often dangerously polluted.

3. The pressure on the private systems at times, if not continually, is higher than the pressure on the public supply.

4. Check valves or gate valves separating the two supplies are unsafe and unreliable means of separating the supplies, since analyses of the underlying factors clearly indicate that in spite of mechanical perfections these mechanisms fail to function properly, not only because either supply contains substances interfering with positive action of check valves, but also because of the lack of human control to continually watch such installations, as well as to prevent tampering with or manipulation by ignorant employees. This finding also applies to the type of installation designed by the Associated Factory Mutual Fire Insurance Companies, approved by them and recommended by the National Board of Fire Underwriters.

5. Numerous epidemics have actually been caused through faulty cross-connections, causing losses totalling millions of dollars.

6. Waterworks officials, private engineers and health officers, except in places hit by the epidemics above mentioned, are unaware of the magnitude of this menace which, in addition to lack of supervision and education to ferret out all cross-connections, constitutes even a greater menace which cannot be overestimated.

The remedy is to discontinue all cross-connections with polluted supplies and rightly all cross-connections regardless of quality of water. By slight cost to existing installations and proper consideration for new ones, all the benefits from use of dual supplies will be secured and the two kept separate, if the city supply feeds separate systems throughout or is made to discharge overhead into pumps, tanks or towers, either for gravity or pump supply to the private system. Tank supplies in some cities are just as acceptable to the insurance companies as a direct connection. However, where the pressure on the public supply is unreliable or uncertain, booster pumps can be installed for emergency use to raise the city water to elevated tanks, in which case the fire protection would be increased.

The recommendations are the usual conclusions made by health officials of cities and states which have suffered heavily from epidemics due to this cause. The cities of Lowell and Philadelphia and the states of Washington and Minnesota are the only localities requiring complete separation of the two supplies. Ohio, except for temporary tolerance of some cross-connections of the double check valve type, also insists on complete separation. Pennsylvania and

California require separation except where both supplies are under state permits.

So far as is known, no other state has any regulations regarding cross-connections, the chief reason undoubtedly being a genuine lack of appreciation of the importance of this subject.

Health officers should coöperate with waterworks officials, find out where cross-connections exist, require separation and in the case of opposition refer the matter to the state by citing the private company to make application for their water supply, as required by resolution of the California State Board of Health, dated November, 1919, and amended May 12, 1924.

THE INVISIBLE BALANCE SHEET[1]

By Warren R. Voorhis[2]

A prosperous utility is proud of its balance sheet. It is printed on folders and stamped on blotters; it waves from the masthead. It is necessary for a utility to have a balance sheet, but this admission leaves us free to say that a balance sheet is a form of literature distinguished by a conspicuous lack of charm.

It is an invention of accountants, an unimaginative tribe, and is an attempt to picture a business by arithmetic, a medium which is deficient in flexibility. Figures may be made to tell the truth; they cannot be made to tell the whole truth.

It may be truthfully said of one of Sargent's pictures that it is 4 feet high and 5 feet wide, and contains 20 square feet of canvas; but these statistics do not fully develop the idea of the picture.

I do not say that a certain amount of information about a utility cannot be gathered from a balance sheet by those who are trained to that somewhat dismal trade, but I do assert that some very valuable assets and some serious liabilities are never shown there.

GROUNDS AND BUILDINGS

I like to study the items of the balance sheet of a public utility with which I am acquainted; for example: "Station Grounds and Buildings, $290,000." This is an attempt by arithmetic to describe these buildings and structures.

But I see a sweep of broad river, curving about a level place set about with trees, with a high green hill rising behind it. The buildings are of gray slate, warm red brick, and white stone; the waters in the reservoir are shining in the sun. The driveways are

[1] Reprinted from the Electrical World, Vol. 87, No. 15, April 10, 1926, page 756.

Not often is it so freshly emphasized, as in this article, that "beauty" of spirit and of matter, is not in conflict with "use."—*Editor*.

[2] Vice-President of American Water Works & Electric Company, New York, N. Y.

marked with whitewashed stones, which is old fashioned, but green grass and whitewash are the cleanest combination in the world. The entrance gates are open and people sit about under the trees, and children run about in the grass with never a $5 fine sign to stumble over.

The chief engineer, tilted back in his chair by the door of the boiler house, watches the sun drop into the river. And the dog of the firemen mitigates the austerity of his guardianship with a benevolent toleration for the rights of humanity. This pump station does more than pump water—it is a place of peace and quiet beauty. And the town is proud of it, as every town ought to be able to be proud of the buildings and grounds of its public utilities.

You cannot see the open gates, and the whitewashed stones, and the green grass in the balance sheet, because beauty eludes words, as well as arithmetic. But as long as people continue to love such things, they should be listed in the "invisible balance sheet" as valuable assets.

One time I visited a utility property and was shown the balance sheet. One entry read: "Office Furniture and Fixtures, $6000." My respect for the meticulous accuracy of accountants does not permit me to make actual changes in a balance sheet, but mentally I multiplied the $6000 by three and transferred the whole item from the asset to the liability side.

Those fixtures and that furniture produced in that office an atmosphere of settled, permanent melancholy and solid gloom which remains in my memory to this day. The walls were painted a deep, durable green; the places from which calendars and pictures of candidates had been removed were lighter in color. The eye rested with relief upon a white place in the ceiling where the plaster had fallen away.

The centerpiece of the office was the office stove. It stood on its four legs on a piece of zinc with an iron pan underneath for ashes and a rusted nickelplated urn on top for ornament. The color of this stove was red at the bottom, fading to gray at the top.

The stovepipe wavered upward for 6 or 8 feet and then definitely angled away about 20 feet to a hole in the wall. This pipe was supported by rusty wires from the ceiling, and the wall around the hole where the pipe escaped was black with soot.

The space for the public was divided by a partition from the space for the inmates. There were two holes in this partition; over one it

said, "Complaint Department;" over the other it said, "Pay Here." The linoleum in front of the complaint window was worn down to the bare boards. As a rule I am opposed to a "Complaint Department" in a utility office, but it did harmonize with this office.

In the public part there was never a bench or a chair where a woman could put her package or her baby while she fumbled for the bill she must produce at the "Pay Here" window. The wall desk for public use was so cleverly placed to avoid all light that it could not have been accidental. This was probably pure malice. Finally, the lower half of the front window was painted a dead black.

A man in that town told me that once he went to this office to pay his bill and that he took his dog. And that man said that all the time he was there this dog sat down and howled and would not be comforted until he was once more out in the sunshine. I do not think that the man intended me to take this story literally, but he did mean to tell me how that office affected him, and just made up the part about the dog.

Now in the "invisible balance sheet" where should this furniture and these fixtures be placed? As long as people get impressions from material things, as long as they are affected by their surroundings, such an office is a heavy, self-inflicted liability, regardless of accountants and arithmetic.

CHIEF ENGINEER'S SALARY

I have been looking at the income account of a utility that I know very well. An "income account" is another contrivance of accountants, with the same limitation as the balance sheet. There is an item: "Chief Engineer's Salary, $4200." This is the best the accountants can do for John Evans.

The service record in our office shows that John Evans began work at the station where he is now chief engineer, April 20, 1886. Forty years. A working lifetime spent in one place, doing one thing.

When I go to this plant Evans always says to me, "In 40 years the town has never been out of water, even for one hour." Every time I go he says this to me. I suppose because he is old now and he forgets that he has told me before. But I think it expressed the dominant note in his life. It expresses his lifelong conscientious fidelity to a responsibility, although John Evans would not dream of putting his day's work in this stilted language and, besides, his repeated expression is much more simple and strong than mine.

Evans has witnessed ten changes of city government in his time, and for many years the young fire chiefs, driving red automobiles against traffic rules, have come out to the station to talk things over with Evans. New plant managers come, stay their apppointed time and depart upon their lawful occasions, and Evans patiently undertakes the education of a new manager, who, if he is a wise young man, will give nearly as much heed to Evans as to the advice from the experts of the home office.

As the years pass the whole organization has become proud of John Evans, proud of his long service, his experience and knowledge of the property, and now, after 40 years, that town is proud of John Evans. He has become a public institution, like the Soldiers' Monument. And the Mayor, who has a fine turn for oratory, says that such a record reflects credit upon Evans and his company and that such loyalty and fidelity and such respect and confidence is the kind of relationship that ought to prevail in all industrial life.

And all the time Evans, a bent man with grayish hair, and the pipe he brought with him to the job, goes about his day's work at the station, one day being much like another. And he says, if you interrupt him, "In 40 years the town has never been out of water, even for an hour."

THE MORAL OF EVANS

I conclude, from thinking of John Evans, that in the making of a man the size of the stage does not matter. Evans lives in a house near the station. He brought his wife there, and from there his children have gone out to lives of usefulness. He has spent all his years at his home or at the station, by the margin of a quiet river just outside a small city. I do not know whether his has been a life of distinction or not, but if loyalty and fidelity and honesty and conscientious discharge of duty enter into the making of success, then by such a standard John Evans has succeeded beyond most of the men of my acquaintance.

I further conclude from the life of Evans that a public utility which has an organization of men and women with something of his conception of duty possesses an asset which belongs in the "invisible balance sheet." Buildings and wires and meters and things terrestrial which can be handled and seen do not of themselves make a utility; the spirit of the business must be found elsewhere. The utility which maintains a relationship with its men and women which

inspires them and puts the spirit of service into the business has an asset which defies arithmetic, because there is no way of measuring its value except by its loss.

ASSETS AND LIABILITIES

This is the end of the moralizing part of my article. The "invisible balance sheet"—in my opinion all directors of public relations should be certified public accountants, relieved, however, from the limitations of figures and qualified to deal with those values which elude the property balance sheet. I would require such directors to keep a balance sheet, constantly revised, and with an understanding that no item in the liability side has there a permanent abiding place; it is to be lifted to the asset side at the first opportunity.

Especially I would not require the "invisible balance sheet" to balance exactly, assets against liabilities, which is the chief obsession of accountants who make the property balance sheet. In the "invisible balance sheet," when there is a balance something is wrong. And finally I would not expect a utility to build up the asset side of its "invisible balance sheet" by large money expenditures, for we were long ago told that the things of the spirit cannot be bought with money.

But good judgment, common sense, tact and unfailing and sincere courtesy, thoughtful consideration for the people we serve and for the men and women who help us serve, these are the expenditures, this the legal tender which effects changes in the "invisible balance sheet."

A public utility with its treasury empty of such currency may with confidence expect to find its regular balance sheet and income account adversely affected, so closely do things invisible impinge upon things material.

PLUMBING AND SERVICE COMPLAINTS[1]

By V. E. Perry[2]

Up to about 1890 the Spring Valley Water Company used as a standard for house services a ½-inch driven tap with a ½-inch lead service pipe, and from 1890 to 1908 used ⅝-inch driven taps and ⅝-inch lead services. In 1908 we adopted as a standard for residential and small commercial services a ¾-inch screw tap with a ¾-inch galvanized pipe service.

These changes were brought about by an increasing per capita water consumption due to a change in the plumbing conditions, as shown by the following record of population and water consumption:

PERIOD	POPULATION (U. S. CENSUS)	CONSUMPTION	
		Total.	Per capita
		gallons	*gallons*
1880	234,000	12,648,000	54
1890	300,000	20,416,000	68
1900	343,000	25,644,000	74.2
1910	416,900	35,604,800	85.4
1920	508,400	36,167,700	71.1

In 1918 the entire city was metered, which accounts for the decrease in water consumption as shown in the above table. There being a decrease of 16.7 per cent or about ⅙ in the per capita consumption for the decade 1910 to 1920, due to metering.

The first patent toilet was a "pan" water closet, which had an inverted conical bowl with a pan at the bottom and was operated by a pull up handle in the toilet seat. The pulling of the handle dropped the pan and also operated an automatic valve not unlike (in its operation) the present flush valve. This threw a small stream around the sides of the bowl. The dropping of the handle raised the pan and

[1] Presented before the California Section meeting, October 16, 1925.

[2] Assistant Manager of Water Sales, Spring Valley Water Company, San Francisco, Calif.

allowed the valve to close. These toilets together with a wooden or zinc lined sink, a small marble wash stand and an occasional zinc lined bath tub, were amply supplied through a ½-inch service and a ½-inch house pipe. Later for sanitary reasons the Golden Gate Toilet was adopted. These toilet bowls held from two to three gallons and together with the increasing use of bath tubs and the discontinuance of the roof tank, because of the adoption of the galvanized range boiler in place of the copper one, made it necessary to increase the size of the service and the house piping.

Still later the introduction of the high tank, then the low tank in toilets, together with shower baths and instantaneous heaters, required another increase in the standard size of the service and also in the house piping.

I might hazard a forecast that the time is not far distant when we shall again have to increase our standard services in order to provide for the more modern plumbing such as flush valve toilets, and side spray showers, etc., which are now generally used and which require oversize services and house pipes.

These changes in the plumbing conditions have brought about a number of complaints of "poor pressure," by consumers who, having installed too small a house pipe, could not get sufficient water for the proper operation of such fixtures as shower baths, instantaneous heaters, etc., and asked the water company to investigate the situation.

In all cases where the size of the service was less than the present standard ¾-inch we have increased it, with the understanding that, if this did not remedy the condition complained of, the consumer would increase his house piping. The wisdom of this policy of increasing services in advance of the house piping is apparent for it changes the responsibility of good service from the company to the consumer.

Our dealings with the plumbing fraternity in general have always been pleasant, but occasionally one of the smaller members of the craft will cause the water company considerable annoyance by his lack of knowledge of some of the common factors in hydraulics, such as frictional loss being called "poor pressure," and instructing his client that it is "up to the water company to increase the pressure," usually a physical impossibility. When the water company is called upon to remedy these conditions our investigation invariably develops that the cause is due to the small size of the house pipe or the service pipe or both.

There were 65 cases reported on during May, June and July of 1925. Of these there were 48 cases where the services were the same size or smaller than the house pipe and 17 or 26 per cent cases, where the house pipe was less than the size of the service pipe. Of the 48 cases where the service pipe was the same size, or smaller, 12 of them or 27 per cent were for $\frac{1}{2}$-inch services with $\frac{1}{2}$-inch house pipes. In round figures about 45 per cent of the complaints are due to too small house piping.

The premises examined showed pressures ranging from 25 to 78 pounds with an average pressure of 43 pounds. From this record it will be seen that the pressure conditions are not altogether responsible for the complaints, and as shown above it is more often caused by the sizes of the house piping or the service pipe, than from the pressure conditions.

The complaints ranged in house size from one-story bungalows to six-story office buildings and in character from lumber yards to sausage factories and hotels to apartment houses.

In conclusion, we believe that a little more coöperation between the plumbers and the water company would greatly reduce the number of complaints of "poor pressure" and speaking for our company we will heartily approve any act that will bring about this coöperation.

WATER SUPPLY AND SEWAGE DISPOSAL OF THE GREAT LAKES CITIES[1]

By Joseph W. Ellms[2]

In 1911, the United States Public Health Service completed a sanitary survey of the entire watershed of the Great Lakes on the United States side of the boundary. This investigation as reported by Dr. A. J. McLaughlin of the United States Public Health Service, stated that "In certain localities on the Great Lakes and in their connecting waters dangerous sewage pollution was shown to exist but the bulk of the Great Lakes waters remains in its pristine purity; that the colon bacillus is practically never present in the unpolluted waters, and that the normal bacterial content of Great Lakes waters is less than 10 per cubic centimeter."

The dangerous contamination of the lake waters arises, of course, from the discharge of sewage from towns and cities located on the shores, from vessels nagivating the lakes, and from surface wash from rains and thaws. The distance polluted water may travel depends upon its volume, the natural currents produced by the flow of waters between the lakes, as in the Detroit and Niagara Rivers, and the currents induced by wind action. It was found that at the mouths of the Detroit and Niagara Rivers serious pollution extended normally more than 10 miles into the lakes, and sometimes was found 16 to 18 miles from the shore. At Cleveland, Ohio, contaminated water may be found at times as far out as 8 miles from the shore.

The high natural purity of the waters of the Great Lakes is, therefore, to a great extent of merely academic interest, so far as a source of water supply is concerned, particularly in the neighborhood of our large cities. The high cost of intake and long tunnels, and the engineering difficulties involved in constructing such works in water over 70 feet in depth, force the conclusion that efficient purification is usually necessary for the maintenance of a safe water supply, and

[1] Presented before the Central States Section meeting, October 9, 1925.

[2] Engineer of Water Purification and Sewage Disposal, Cleveland, Ohio.

that further means for diminishing the load on water purification processes must, in many cases, also be undertaken.

In 1904 the late Prof. G. C. Whipple made an investigation of the sanitary quality of the waters of Lake Erie opposite Cleveland. In 1920 the writer made a similar study covering about 250 square miles opposite the city and its suburbs. Again in 1924 another more limited area of about 36 square miles was investigated for the purpose of locating a new intake. Comparing the results obtained by Professor Whipple in 1904 with those made by the writer sixteen years later, it was evident that the zones of pollution had increased in area, and that contaminated water had forced its way much farther out into the lake. The studies made in 1924 on a smaller area corroborated those made previously.

The economic importance of the Great Lakes in commerce has, in a large measure, been realized. But the natural advantages of these waters as a source of pure water supplies and for recreational purposes have not been similarly appreciated. The natural clarity of these waters for a greater portion of the year led to a belief that they must necessarily be pure and fit for consumption without purification. This idea during the past fifteen years has been gradually changed as a result of the overwhelming evidence obtained in cities located on the shores of the lakes whose inhabitants suffered from water-borne typhoid fever epidemics, and other intestinal diseases. On the other hand, far too little has been done toward diminishing pollution of the waters of the lakes by more complete purification of the sewage discharged into them.

There is no question that the natural resources of dilution should not be availed of; but it should also be realized that there must be a limit to the ability of purification processes to make safe, from a sanitary standpoint, waters which have once been contaminated.

The only source of water supply for cities and towns on the Great Lakes is lake water, and the only place for the ultimate disposal of the liquid portion of the sewage is this same lake water. The question, therefore, arises as to how far can we safely go in disposing of sewage in the lakes without treatment, or even with partial treatment, before the water supply becomes so badly contaminated that purification processes become overloaded. Moreover, is it a proper policy to pursue to encroach too closely upon the barriers set up by filtration and disinfection? Where is the safe limit, from a sanitary standpoint, beyond which it is dangerous to go?

The writer is well aware that the economics of water purification versus sewage treatment need serious consideration in each case. Nevertheless, we do not question costs where life and death are at stake, nor should we do so in this situation. So long as we huddle ourselves together in large cities, we must pay the penalty of concentration. Sanitarians have a grave responsibility in this matter, and they should not shirk it. Too little vision of what the growth of our large cities means is far too common. It is necessary to look forward, and to provide in our engineering structures and in our processes for growth and for concentration of population. If we do not, the evils of insanitary conditions may be upon us before we realize our mistake.

The public are being educated in matters of sanitation and are demanding and will continue to demand more effective measures for the disposal of sewage and of trade wastes, not only for reasons of health, but of ordinary decency.

The cities on the Great Lakes are in a peculiar position regarding water supply and sewage disposal. They are all of them fouling their own nests. Whether they realize it or not, the problems of a safe water supply and the proper and adequate treatment of their sewage are so intimately related that one cannot be solved without solving the other.

RE-LINING THE VERONA RESERVOIR[1]

By Charles L. Crosier[2]

The Suburban Water Company supplies water to the boroughs of Oakmont and Verona, which are situated on the Allegheny River approximately 12 miles north of Pittsburgh, and to parts of Penn and Plum Townships and also to North Bessemer. The works of the Company consist of a pumping station and filtration plant on the east bank of the Allegheny River; the Verona distribution reservoir supplied by two main feeder lines; an 8-inch pipe line leading from the reservoir about two miles northeast to the McAbee booster pumping station; and a distribution reservoir in North Bessemer some two miles further southeast.

The Verona distribution reservoir was re-lined a few years ago and this work is the subject of this discussion.

ORIGINAL RESERVOIR

The reservoir is located on a hill about two miles north of the pumping station and about a mile east of the Allegheny River. Its flow line is at elevation approximately 1100 or about 400 feet above pool level in the river.

The old reservoir built in 1897 was of the earth cut and embankment type, with clay puddle lining and with the side slopes and bottom paved with brick. The reservoir had a water depth of 16 feet, top plan dimensions of 125 feet by 145 feet and a capacity of approximately 1,500,000 gallons.

In 1919 a leakage test was run on this reservoir and the drop in water level was found to be approximately 4½ inches in twenty-four hours. This is at the rate of about 50,000 gallons per day.

RE-LINING THE RESERVOIR

The re-lining of the reservoir was done in the late summer and fall of 1921. The re-lining amounted almost to an entire reconstruction,

[1] Presented before the Central States Section meeting, October 10, 1925.

[2] Division Engineer, Cleveland Office, Morris Knowles, Incorporated, Cleveland, O.

inasmuch as the only part of the old reservoir used was the earth cut and embankment. The brick pavement was replaced with a pavement of reinforced concrete slabs, 6 inches in thickness. The depth of the reservoir was increased by constructing a wall around the top of the embankment, four feet in height. The new reservoir is practically the same size at the top as the old reservoir, being 145 feet 6 inches by 126 feet three inches. This provides a total depth of water of 20 feet and a capacity of approximately 2,000,000 gallons.

DESCRIPTION OF PAVEMENT

The side slopes are divided into slabs 10 feet by 15 feet in size. These were cast separately. These slabs rest on footers and the spaces between the slabs as well as the surfaces between the slabs and footers are either filled or joined with asphalt so as to prevent bond. This is done so as to have definite points at which contraction takes place, to prevent cracking of the concrete. Most of the slope paving slabs were poured with top forms, which were held down by sand bags. Some of the slabs in the corners and a few others were poured without forms, but the concrete had to be rather dry in order to keep it from flowing down the slope, and in general, better results were obtained by the use of top forms. The finishing wall around the top was poured in sections 35 feet long, with expansion joints between sections.

MISCELLANEOUS CONSTRUCTION

A 4-inch open tile drain surrounded by gravel is placed under the finishing or parapet wall around the top; and a similar tile drain is placed at the bottom of the reservoir on its uphill end and sides. These drains are to take care of any seepage which may occur, and the one at the bottom was also intended to take care of seepage from the hillside and a small spring which was encountered at the reservoir site.

A 16-inch line, laid under the reservoir and terminating at the center, serves as both a supply and outlet pipe. This 16-inch line extends about 1 foot above the bottom of the reservoir, so that any mud or dirt settled at the bottom will not be withdrawn into the distribution system. A screen is also placed on the end of the pipe, so as to prevent the entrance of leaves or other foreign matter. This line has an 8-inch connection which can be used as a drain for the

reservoir, by removing a blank flange, as it is placed low enough to drain the entire reservoir.

An altitude valve in the outlet line is provided to prevent the reservoir from overflowing. However, as a factor of safety, in case of failure of the altitude valve to operate, an overflow pipe is provided.

An ornamental fence was provided around the top of the finishing wall. Connection to the wall was obtained by using 2-inch sleeves placed in the wall for a depth of 8 inches, and 8 feet on centers, to hold the posts of the fence.

COST OF THE WORK

The re-lining of the reservoir cost approximately $20,000. As was mentioned before, the only part of the old reservoir that could be used was the excavation and embankment. The amount of material involved in this was approximately 6000 cubic yards, and the cost of the excavation and embankment would be perhaps $10,000. as a maximum figure. Therefore, it may be assumed that the reservoir on the basis of entirely new construction, would have cost approximately $30,000. This gives a reasonable total cost, as it would amount to about $15,000 per million gallons of capacity.

RESULTS OBTAINED

An inspection was made of the reservoir by A. G. Garvin, President and General Manager of the Suburban Water Company, and J. A. Fulkman of this office, in August of this year. It was found that the vertical walls at the top of the slope paving were in excellent condition after four years of service. None of the walls or slopes were bulged or out of alignment. Where certain of the sleeves are inserted for the fence posts there are small contraction cracks, both on the inside and the outside of the wall, extending about 18 inches from the top of the ten inch wall. There are a few points where the sleeves are within a foot or 18 inches of the expansion joints, where the cracks have not occurred. This is, no doubt, due to the sleeves being close to the expansion joints. These cracks might perhaps have been prevented, had there been additional horizontal bars in the wall near the top.

In general, in concrete structures of this nature, as well as concrete roads, it appears that the best way to take care of contraction is by providing a sufficient number of joints. Even then it is not always

prevented, and it may be necessary in some instances, after all due precautions have been taken, to let them crack, just as General Goethals said in reference to the Bigelow Boulevard Slide in Pittsburgh in 1920, "You will have to let it slide."

The Verona reservoir has a pleasing appearance, although it is not in a location where a large number of people see it, and without any special emphasis having been placed on that feature in the design. The finishing wall and the iron fence around the top add materially to its appearance. Such a finishing wall has a decided advantage where a reservoir has to be built in a location of limited area, as it adds capacity without increasing either the slopes or the surface area. Reservoirs of this type can be built in high class residential districts, in parks or at country clubs, as the presence of such a body of water adds to, rather than detracts from, the appearance of the landscape.

ALGAE IN WATER SUPPLIES[1]

By N. L. Huff[2]

The algae of our water supplies are minute forms of plant life, often too small to be seen with the naked eye. In structure they rank among the simplest of plants, yet in their conquest of the earth they have been preeminently successful. They are found in lakes and rivers, ditches, ponds, reservoirs, in fact wherever natural waters are exposed to the light. In the economy of nature they play an important rôle for they are the ultimate source of food for practically all of our fish and other animal life of pond and stream. In small lakes and reservoirs, however, there is often an over-production, they form offensive accumulations and may even become a menace to public health.

In large and deep lakes where the temperature is low the water may be almost of crystal clearness, yet a plankton net drawn through the water, or a fine sand filter will separate out countless millions of these minute organisms. But it is in shallow lakes and sluggish streams where the water reaches a high summer temperature that they find conditions most favorable for their growth and development. It is here that they form massive scums and ill-smelling slimes so familiar to all who have had experience in storing water in open reservoirs and small lakes.

When present in small numbers algae are not injurious to health nor are they particularly objectionable. If abundant, however, they not only become displeasing to the eye, but certain forms produce offensive tastes and odors that render the water unfit for domestic use. The troubles caused by these aquatic plants are universal. Not only do they produce greenish or brownish colors and a turbidity highly objectionable, but tastes and odors in water supplies can more often be traced to algae than to any other source.

Attempts to classify tastes and odors caused by algae have been

[1] Presented before the Minnesota Section meeting, November 13, 1925.

[2] Assistant Professor of Botany, University of Minnesota, Minneapolis, Minn.

numerous but never, I think, very successful. Such terms as musty, aromatic, woody, and grassy are often used to describe the odors of certain algae, but these terms are rather vague and not therefore very satisfactory. In some cases living algae have a characteristic odor especially when present in great quantities. Certain diatoms when abundant may impart to the water a fishy odor and it seems probable that this odor arises from the living organisms rather than from the few dead or disintegrating forms that may be present. Some of the blue-green algae have an odor when living and growing that is decidedly characteristic, and very different from the offensive odors given off with disintegration.

Algae most troublesome in water supplies fall naturally into two large groups, the *green algae* (Chlorophyceae), and the *blue-green algae* (Cyanophyceae). The first of these groups is the less objectionable of the two and for our purpose may again be divided into three groups. One of these consists of unicellular and colonial forms of bright green color, usually free-floating, drifting with the water currents but remaining within a few feet of the surface. Members of this group often impart a greenish color to the water, but they seldom form scums and are not often present in sufficient quantities to be highly objectionable. The second group of green algae, including the filamentous forms, is more objectionable. Members of this group do not ordinarily produce odors, but they accumulate in filthy-looking masses forming scums that are unattractive to say the least. Some of these have attachment organs by means of which they cling to stones or submerged water-weeds and so long as they remain completely submerged are not highly objectionable. Often however they form tangled masses which break loose from their moorings and come to the surface where they continue to thrive for the rest of the summer. Other forms have no attachment organs and from the beginning are free to form objectionable surface scums.

As a result of certain life processes green plants give off oxygen when growing in the sunlight. In submerged filamentous green algae this gas often collects in the meshes among the filaments until the whole mass is buoyed up to the surface forming the familiar scums. If no pond-weeds or other plants are present to support the mass at the surface it may settle to the bottom at night or when the oxygen in the meshes among the threads has escaped. But the light of another day will generate more oxygen, and again the mass will rise to the surface. Sooner or later the raft-like mass drifting hither and

thither with winds and waves may find anchorage among the stems of pond-weeds or bulrushes and here it may continue to thrive as a pond-scum for the remainder of the season. Algae of this type are comparatively long-lived, a given individual may persist for the entire season. They are practically odorless and even at the end of the season when they die and disintegrate the process is a slow gradual one and is not accompanied by disagreeable odors as in case of the blue-green algae. From the aesthetic point of view however they are highly objectionable, and should be eliminated early in the season, or whenever they begin to form conspicuous scums on the surface.

The third group of green algae troublesome in water supplies is that very large and widely distributed group known as diatoms. They are unicellular forms, often held together loosely in colonies, sometimes attached to water-weeds, stones or other submerged objects, but the most troublesome forms are free-floating. The specific density of diatoms is nearly the same as that of water in which they live and they seldom form scums, but during the summer months may be evenly distributed through that stratum of water which is agitated by winds and waves. In our small lakes this means that they are commonly distributed to a depth of about 20 feet. Below this depth the water is stagnant during the summer and diatoms in this stagnant water are rare or absent. Unlike many of the scum-forming algae that thrive only during the warmer seasons, some diatoms are far more abundant in the cool waters of spring and autumn than during mid-summer.

The green coloring matter of diatoms is commonly obscured by a brown pigment so that when abundant they impart to the water a muddy brownish color. Under conditions most favorable for their development the water may become so turbid that light-colored objects become invisible a few inches below the surface, and the fishy odor characteristic of diatoms may become quite offensive. Not only is such water unsuitable for ordinary domestic use, but on account of strains produced it is unfit for use in laundries or for the manufacturing of paper.

The algae most detested as contaminators of public water supplies belong to that universally distributed group, the blue-green algae. They are minute plants of very low organization, often single cells existing alone. Others form long chains or threads, still others form colonies with thousands of individuals held together by a watery gelatinous matrix. Some of the filamentous forms cling to the mud

or stones in the bottom, but most of the colonial forms are free-floating and being lighter than the water tend to form scums on the surface.

The method of reproduction in these unicellular forms consist in a simple cell division, so that each division results in doubling the number of plants. These divisions occur in rather rapid succession, only a few hours being required for an individual to complete its life cycle. The total number of individuals is doubled or trebled every twenty-four hours, and this rate of increase may continue for several weeks during the summer. The number of offspring arising indirectly from a single individual during a summer is almost inconceivable. Allowing a conservative time of twenty-four hours for an individual to complete its cycle and divide, the offspring from a single individual would in thirty days number 1,073,741,824, if all the offspring matured and divided. Microscopic examination and daily counts from lakes where conditions were favorable for their growth and development, show that they actually do increase at times for a period of several weeks, at a rate in excess of this theoretical case. The fact that not all individuals mature and divide to form two new ones is more than compensated for by the fact that many complete their cycle in considerably less than twenty-four hours.

The cells of these blue-green algae are exceedingly delicate and fragile and it is evident that where multiplication is so rapid the mortality rate is going to be high. Even when living and growing some of these forms are known to emit a disagreeable odor fittingly described as a "pig-pen" odor, but with death and disintegration the odors are intensified and become exceedingly offensive. When abundant they produce scums like green paint or Paris green and with favorable winds their odors may be detected a half mile or more from the lake.

How can we prevent or control the growth and development of these objectionable organisms in our small lakes and reservoirs? The most effective method known at the present time consists in the application of copper sulphate in quantities sufficient to destroy the algae, but not large enough to prove objectionable from the standpoint of the consumer. But when and how shall this application be made to obtain the most satisfactory results and avoid certain objectionable features such as disagreeable tastes and odors resulting from the algae destroyed?

The method of distributing the copper sulphate in lakes and reser-

voirs by dissolving the crystals out from coarse sacks towed behind boats is quite satisfactory and is too well known to need further description here. There are cases, however, where the trouble is caused by definite scums where spraying is a more effective method of treatment.

In regard to the amount of copper sulphate necessary to keep a reservoir free from algae, no rule can be given. The various species of algae are not equally sensitive to copper, in fact some species are very resistant to its effects. Even for a given organism the quantity necessary for its destruction is affected by the water temperature, the amount of organic matter dissolved or suspended in the water, the hardness of the water, and several other conditions. The whole matter is complicated and each case requires particular study and a specific prescription.

A knowledge of the nature and life-habits of the organisms causing trouble is always desirable, in fact is essential if one would use copper sulphate most effectively. Let us consider briefly some of the habits of a few common typical forms:

The unicellular green algae are not as troublesome as some others, but occasionally they become sufficiently abundant to impart a greenish color to the water. They vary greatly in form and size. Most of them reproduce by division of the cell into two, but some of them form complete little colonies within the parent cell. Some reproduce sexually and form heavy-walled resistant resting spores. The Desmids are of varied and artistic design, usually constricted between the two half-cells. They occasionally form resting spores but more commonly form new individuals by division of the old cell into two. Copper sulphate is most effective if applied during the period of great vegetative activity. The resting spores are probably not affected by small quantities of copper sulphate that prove fatal to the actively growing cells.

Pediastrum is sometimes very abundant in shallow lakes with muddy bottoms. It consists of a colony of individuals arranged in a beautiful design, radially symmetrical. Each individual is independent of the others and may form within itself an entire colony of new individuals.

The water-net (Hydrodictyon) consists of cylindrical thread-like segments connected up to form a lace-like net, often several inches in length. These nets, while very beautiful when viewed with a lens or microscope, float on the surface in great tangled masses and

form unsightly scums where conditions are favorable for their growth. They reproduce by forming an entire new net within each segment of the old net, or by a sexual process which results in the formation of a resistant resting cell or spore-like body that carries the plant over winter. When the water-net is free-floating it is very sensitive to copper sulphate; when lying on the mud of the bottom it seems to be very resistant. The probable explanation for this lies in the fact that the abundant organic matter in solution or in suspension near the bottom consumes the copper before it actually reaches the living cell.

Cladophora is one of the most common of our scum-forming green algae. It consists of rather coarse, profusely branched threads and is often attached to some submerged object. The green mossy growth seen in running streams and under water-falls is often due to this plant. In lakes and ponds it often breaks away from the substratum and forms great raft-like masses that float about the surface or lodge among pond-weeds near the shore. This form is very resistant to copper sulphate, requiring ten times as much of the chemical for its destruction as do many other forms. Fortunately it is most objectionable when it floats on the surface and forms scums, and in this condition it can be destroyed by spraying the surface of the water with a strong solution of copper sulphate. Since the scum at the surface receives the full effect of the spray, this resistant form may be destroyed while more sensitive species at greater depths may escape injury.

Perhaps the most common of all our scum-forming green algae is Spirogyra. It consists of long, unbranched, silky threads, soft and slimy. Under the microscope we see its cylindrical cells arranged end to end, each with one or more green ribbon-like bands wound spirally within the delicate transparent wall. The reproduction in this plant is usually sexual, the male and female gametes from different cells uniting to form a heavy-walled resistant spore which carries the plant over winter. Spirogyra is one of the most sensitive of our algae to copper sulphate, one part in ten million being sufficient to destroy most of our common species. To be most effective the copper sulphate should be applied during the growing period preceding reproduction. The resting spores are not affected by ordinary copper sulphate treatment of the water.

Pond-felt (Vaucheria) is more commonly found growing in the bottom of ponds and springs, in shallow water. Its filaments are

branched, but not segmented. Its common method of multiplication is by means of motile, non-resistant, spore-like bodies, but at certain seasons it too forms the resistant resting-spore to carry the plant over winter.

The diatoms constitute an interesting group of organisms. Each individual is one-celled and is enclosed in a transparent, siliceous, glass-like wall consisting of two valves one overlapping the other like a pill-box and cover. The valves are marked or sculptured with numerous regular transverse lines. Some species grow on stalks, attached, others solitary or in colonies. In form they vary greatly, rods, cylinders, disks, wedges, or boat-shaped, but all are of definite geometrical design. This most common method of reproduction consists in cell division, a process in which the two halves of the siliceous wall separate from each other and each forms a new half. Some species however may give rise to a very large number of minute individuals within the wall of the parent cell. These are liberated and develop rapidly into the adult form. During the summer months when the water temperature is high (60° to 80°F.) these may respond quickly to copper sulphate treatment, but during the spring and autumn overturning when the water temperature is low and great quantities of dissolved or suspended organic matter are present in the water, they are but little affected by heavy treatments of copper sulphate. They may normally disappear soon after the period of circulation has passed and it is doubtful if a moderate quantity of copper sulphate will hasten their disappearance at this time.

The blue-green algae are very common and are most fragile and most objectionable of all our water-supply algae. A drop of water taken from near the surface of lake or pond may, under the microscope, show thousands of individuals representing many different species.

Clathrocystis consists of single cells held together loosely in colonies by a gelatinous matrix. Reproduction consists in simple cell division, and the rate of increase is very rapid in warm weather when conditions are favorable. Heavy-walled resistant spores are not formed so far as known, and elimination of this species with copper sulphate is comparatively easy.

In Oscillatoria the disk-like cells form threads the ends of which commonly oscillate through a small arc when the plants are actively growing. In Lyngbya the cells are disk-like but a heavy sheath is present and movement is lacking. Both of these forms are more

commonly found in the bottom in shallow water, and they thrive best in the presence of sewage or decaying organic matter, but occasionally cause trouble in public water-supplies. They do not produce heavy-walled spores and are responsive to moderate quantities of copper sulphate.

Anabaena, one of our most troublesome water-supply algae, is represented by several common species. Its cells are joined in chain like chains of beads. Its increase during the summer is due to a rather rapid division of its cells and threads, but it forms heavy-walled resting spores for carrying the plant over winter. It is one of the most sensitive of algae to copper sulphate, but for best results it should be destroyed before the spores are formed.

Aphanizomenon sometimes becomes very abundant in certain lakes, but is less common than Anabaena and Clathrocystis. Its filaments are arranged in loose bundles but with little agitation of the water these bundles are broken up. It has less of a tendency to form scums than other troublesome forms but gives a blue-green color and a turbidity to the water. It is carried over winter by heavy-walled resting spores.

In Rivularia we have a tapering thread resembling a whip-cord in form. The resting cell is formed near the basal end. This form grows in colonies that float near the surface and is commonly found along with Anabaena and Clathrocystis.

All of the blue-green algae which cause trouble in our water supplies are sensitive to copper sulphate and disappear within three or four days after treatment. The disappearance of course is due to the complete disintegration of the plants, and since decay of organic matter is usually accompanied by the liberation of gases, and the gases here liberated are ill-smelling, best results are obtained by treating as soon as they have begun their rapid multiplication, and before heavy scums have been formed. The destruction of small numbers of algae, even such forms as Anabaena and Clathrocystis is not accompanied by odors that can be readily detected, and if the treatment is made at the proper time there should be no ill after-effects. It is the delayed treatment that is followed by objectionable features. In case of spore-forming species the best results are obtained by treating before the spores have been formed, since resistant spores may not be affected by the copper sulphate that would destroy active plants.

In all cases where troubles frequently arise from algae, microscopic

examination of the water should be made daily by one who understands the organisms and their habits of life. Any tendency on the part of troublesome forms such as Spirogyra, Anabaena, and Clathrocystis, to increase rapidly should be checked at once by the proper application of copper sulphate. If this is done there can be no serious after-effects of odors and tastes due to accumulated masses of objectionable algae.

SERVICES AND METERS[1]

By E. V. Buchanan[2]

Water works in London, Ont., were established in 1878. The source of supply was then entirely from springs, and remained so until 1909, when the original source was augmented by artesian wells. The water is comparatively hard, the total hardness being in the neighborhood of 30 grains per Imperial gallon. Otherwise the supply is excellent, being pure, clear, and palatable.

It has always been the practice of the water works department to lay small services free of charge to a point 20 feet inside the street line, at the same time providing curb cock and box, cellar hydrant, and meter. The original domestic service was lead pipe $\frac{3}{8}$ inch diameter, which was later abandoned and $\frac{1}{2}$-inch pipe adopted. The first $\frac{1}{2}$-inch pipe used weighed 5 pounds per yard, but for many years only pipe of 6 pounds per yard has been used. The consumer pays the total cost of the larger services except that an allowance is made for the cost of a $\frac{1}{2}$-inch service, if the small service has not already been laid on the lot. The average length of services is 60 feet, there being many streets of 132 feet in width and also the 20-foot allowance on the owner's property to consider. The average cost of labor and material is $30, but the consumer is charged 55 cents a foot for all pipe over the 20-foot allowance.

PROTECTION FROM FROST

It has been the practice until recently to lay all services before pavement is put down, as public sentiment is very strongly against breaking up asphalt and concrete. It has been found, however, that with the main laid in the boulevard, services can be pushed under the pavement by means of a pipe-forcing jack and using lead-lined wrought iron pipe. The laying of services in advance of the pavement is usually a great waste, as lot lines are subject to change and the unused services are left to break away and leak.

[1] Presented before the Canadian Section meeting, March 5, 1926.

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Services like mains are laid with 5-foot cover and very little trouble is experienced from freezing. There has been one or two years of severe cold when there has been an epidemic of frozen services. In these cases, the electrical department has done good work in thawing by electric current. The greatest amount of trouble occurred on streets that had been re-graded after the services had been laid. Now-a-days, the city engineer gives permanent grades, which prevents expense in lowering mains and services. No services that the department has laid have been frozen in the past five years, although some freezing has taken place on service pipes extended by the consumers themselves. With all services metered, it is practically certain that taps are not being allowed to run to prevent freezing, and this proves that the pipes are well below the frost line. Services are always laid to the lot from the street on which the house faces, and driveways are avoided. Records are made on cards giving the location of the curb cock by reference to the two street lines.

SIZES OF LEAD PIPE

Lead pipe has always been used for ½-inch, ¾-inch and 1-inch services. For 2-inch galvanized wrought iron is used, and cast iron for 4-inch and larger.

The water being hard does not occasion any trouble from lead poisoning, and little or no deposits are formed on the pipes. Pipe removed after forty years' service is found to be quite clean.

There has been some discussion recently regarding the size of domestic services, but, although the ordinary pressure in some districts is quite low, averaging about 40 pounds, few complaints are heard. Automatic water softeners and flushometer toilets seem to call for larger services, but the trouble in these cases, where the service pipe has already been laid, can probably be overcome by means of a tank partly full of air.

Tapping machines are always used for inserting the corporation cocks in the mains. These cocks are usually inserted at an angle of 45 degrees, which gives a good "get away" for the lead pipe. The corporation cocks are provided with a lead flange coupling and lead goosenecks are used in the case of wrought iron pipe services.

The standard curb cock box is a Buffalo type box, made locally.

The curb cock with a lead flange coupling is used, the cock with the lead pipe bushing and rubber washer being abandoned some years ago on account of trouble with the washer. The curb box and cock rests on a pine wood block, 1½ inches by 8 inches square, which holds the cock fairly securely in place. Cocks with stop checks are preferred.

Before the installation of meters, it had been the practice to use cellar hydrants with a hose connection, but following the use of meters it became necessary to install the meter on the street side of the hydrant to prevent the unauthorized use of water from the hose connection. This was an unsatisfactory arrangement as the cellar shut-off should be as close to the service entrance as possible, and should also control the meter. An ordinary stop and waste cock is now used and is much cheaper to install than the old type. All brass work is tested on a test bench to 175 pounds per square inch.

In new subdivisions where there is plenty of space and no obstructions, the "Buckeye" trenching machine can be used to advantage to do the excavating, but generally speaking, it is too unwieldy. It is said that smaller ditching machines on the market can do this work economically in nearly all locations.

A steel point on the end of a 1-inch pipe was at one time used successfully for driving distances of not more than 12 feet, but a pipe-forcing jack is now used with a 1-inch pipe, which is withdrawn, and the lead then passed through. In the majority of districts it is possible to force lead-lined galvanized iron a distance of over 24 feet. This, of course, is not withdrawn, but is used as the service pipe.

The men of the service gang are taken to the job along with the material, on a 2-ton truck. The foreman makes out cards showing the time of men, and all material used. The amount of material and labor to be charged the consumer is also recorded, as well as the measurements for locating the curb cock. The service installation order from the general office is returned from the workshop when the job is complete, giving all of the above information.

When applications are made at the office for services for vacant lots, the applicant is given a small sign mounted on a spike which he drives into the ground on the line on which he prefers the service and on the building line.

ESTIMATES FOR COPPER PIPE

As much interest has been created by the suggested use of copper pipe, the following estimates have been made:

60 feet of ½-inch lead pipe	$16.50
½-inch corporation cock	1.03
½-inch curb cock	1.79
	$19.32
60 feet of ½-inch copper pipe	$ 9.44
½-inch corporation cock	1.03
½-inch curb cock	1.79
Two ½-inch copper-to-copper couplings	1.14
	$13.40
60 feet of ⅝-inch copper pipe	$11.10
⅝-inch corporation cock	1.32
⅝-inch curb cock	2.43
Two ⅝-inch copper-to-copper couplings	1.53
	$16.38

It is seen that there is considerable advantage in price in favor of the copper, as compared with lead. The chief objection to lead is its common failure when a sewer or other ditch crosses its line, and no doubt copper would withstand extraordinary stresses better. Tests show that London water does not dissolve or produce any appreciable chemical action on copper. Although no figures are available, it would appear that the loss of head is no greater for copper than for lead, and as the bore is more uniform the friction loss would probably be less. In addition the figures show that ⅝-inch copper can be laid for less than ½-inch lead.

Records of the prices of copper and lead over a period of 15 years show that copper is in a most favorable position. Since 1916 the price of copper has fallen steadily and in the past year has been around pre-war prices. Lead, on the other hand, has been steadily rising since 1921 and is now practically as high as it has ever been. If these conditions are abnormal, as they appear to be, then the advantage of copper pipe from a price point of view may soon disappear.

REASONS FOR METERING

There are two reasons for the use of water meters. The first is that selling water by measurement is the only logical and fair way of conducting the business. The second is that the water meter is the only practical method yet found for restricting excessive waste.

London has for many years metered nearly all industrial and commercial consumers, and has also had a considerable number of domestic meters in use for a long time. Formerly the practice with meters was to place them on request by the consumer, which was a foolish

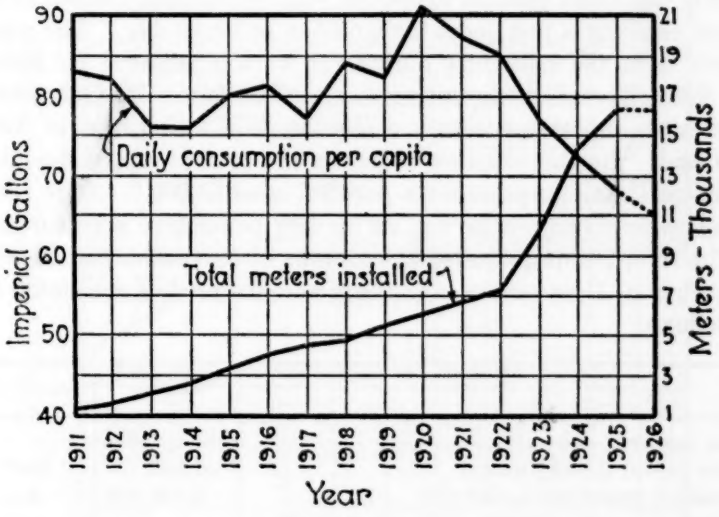

FIG. 1. RELATION OF METERING TO CONSUMPTION

policy, because the consumer who asked for a meter was naturally a careful user, so that no water was saved, the cost of supplying him was increased by the cost of the meter and its maintenance, while in the case of the larger houses the revenue was actually reduced. Four years ago a general policy of metering was adopted, which was practically completed at the end of 1925.

Ten-year debentures were issued for the purpose of financing the scheme, and Canadian-made meters were used entirely to complete the work. The cost of the meters installed averaged $14.

It is difficult to deduce accurately the saving made by the installation of meters, because of varying conditions from year to year.

The lack of rain, the different summer temperatures, and the varying degrees of cold in the winter, all affect the consumption. Changing conditions in business, affecting the number of vacant premises, and the growth in the number of consumers are all factors. Figure 1, however, shows in a general way what has been accomplished. The per capita consumption reached 91 Imperial gallons in 1920, and this year it is hoped it will not exceed 60. The city was supplied from Springbank Station alone until 1909, when there were serious water shortages and when the wells were added, which have been pumping between one and three million gallons a day. In the autumn of 1925 it was found possible to operate with Springbank Station alone, whose capacity is just under three million gallons a day. The water drawn from the reservoirs during the week is replaced by pumping the wells on Saturday afternoons and Sundays. It is interesting to recall a report made to the city by Willis Chipman in 1903, who said: "By the adoption of meters the present supply should be sufficient for all purposes for a population of 55,000." It is easily seen how nearly correct he was, as the city population is now 64,000.

The total pumpage during the months of November and December, when 97.1 per cent of consumers were metered, is accounted for as follows:

	GALLONS	PERCENTAGE
Total pumped	202,284,000	
Water passed through meters	167,236,875	82.7
Estimated consumption, flat rate	4,240,000	2.1
Estimated water for meters out of service or under-registering	4,248,000	2.1
Consumed in iron-removal plant	3,050,000	1.5
Flushing streets	2,756,250	1.3
Drinking fountains and miscellaneous	1,220,000	0.6
Unaccounted underground leakage, etc.	19,532,875	9.7
	202,284,000	100.0

METERS REDUCE CONSUMPTION

The effect of rates on consumption may be interesting. Until 1925 two rates were in use: (1) A flat rate based on the size of the house and the number of conveniences installed; (2) a sliding scale meter rate with a minimum charge. The sliding scale did not affect

the domestic consumer, as the first change did not come until 10,000 cubic feet had been consumed in two months. The minimum charge for a domestic consumer was $1.35 net for two months, and allowed 800 cubic feet of water. This is more than 80 gallons per day and the great majority of domestic consumers do not require this amount.

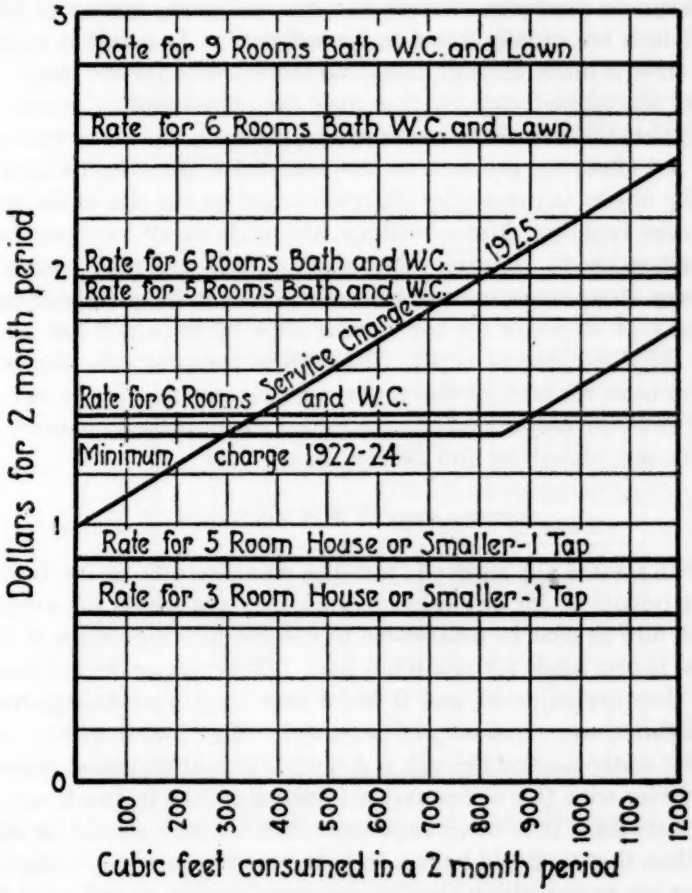

FIG. 2. BI-MONTHLY CONSUMPTION, LONDON, ONT.

The minimum rate was replaced at the beginning of 1925 by a service charge rate, the service charge being $1.00 net for two months. The consumption rate remained the same, viz., 12 cents net per 100 cubic feet. The records for 1925 show that 65,000,000 gallons less passed through the domestic meters than in 1924. or over 12 gallons

a day for every meter. When every drop of water recorded by the meter must be paid for, economy follows immediately. Figure 3 shows the rates which have been used in London, and figure 2 shows the number of bills rendered for varying quantities of water.

Meters $\frac{5}{8}$-inch size are used on practically all domestic services, and even on domestic services as large as 2-inch, meters of $\frac{3}{4}$-inch and 1-inch are usually found to be sufficient. As a rule it is found that error is made through installing meters that are too large. By noting the highest consumption over the meter-reading period it is found that the size of the meter can be reduced, and if the reduction does not affect the pressure on the consumers' premises he does not usually object as the service charge is based on the size of the meter and rises rapidly. Meter readings are made every two months on all meters up to $1\frac{1}{2}$-inch. The larger meters are read weekly, so that any stoppage or excessive consumption can be quickly checked.

The type of meter for the smaller sizes up to 2-inch has always been the displacement type. Although in the past even the larger meters have all been of the single unit current type, it is now the practice to use only compound meters for sizes 3 inches and over. No meters are placed on fire service lines.

METERS TESTED FOR ACCURACY

When meters are received from the manufacturer or are brought in for repairs or for any other reason, they are tested for accuracy within and as near as practicable to the low and high rates of flow. A test is also made for minimum flow. If meters are found inaccurate, they are adjusted, and if found that they cease to register on small flows, are repaired and adjusted. The $\frac{5}{8}$-inch meters must register water passing through a $\frac{1}{64}$-inch orifice at 65-pound pressure. The meter with this orifice records one cubic foot in two hours and fifty minutes. It is more important that a meter should be sensitive than that it should have a high degree of accuracy. Compound meters are tested within the "change-over" range, as well as at high and low rates of flow. A test made recently on a 4-inch compound meter removed from service showed the following results:

2-inch orifice, 100 per cent
$1\frac{1}{2}$-inch orifice, 98.5 per cent
$1\frac{1}{4}$-inch orifice, 98.5 per cent
1-inch orifice, 98.0 per cent
$\frac{3}{4}$-inch orifice, 97.0 per cent
$\frac{5}{8}$-inch orifice, 95.0 per cent
$\frac{1}{2}$-inch orifice, 94.0 per cent
("Change-over" point)
$\frac{1}{4}$-inch orifice, 98.5 per cent
$\frac{1}{8}$-inch orifice, 98.5 per cent

It will be seen that the accuracy falls off rapidly from the 1-inch stream down to the "change-over" point between a ½-inch stream and a ¼-inch stream, and is more or less restored beyond this point.

It has been necessary with the adoption of the general metering to have a systematic re-test period. There is no use metering a system unless the meters are properly maintained, tested and adjusted. The periods decided on are as follows:

⅝ inch, 5 years
¾ inch–1 inch 4 years
1½ inch–2 inches, 3 years
3 inches, 2 years
4 inches–6 inches, 1 year

RE-TESTING PERIODS FOR METERS

The re-test period might be more accurately fixed by the actual duty of the meter than by the number of years in service, and it is

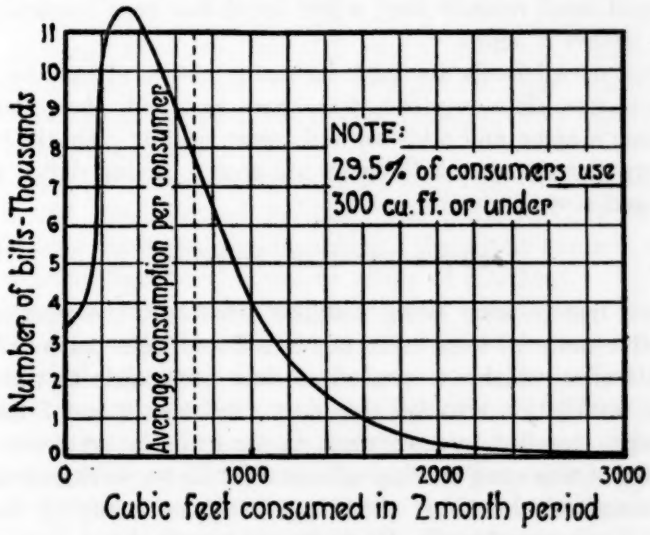

FIG. 3. WATER RATES, LONDON, ONT.
Based on ½-inch meter, with 20 per cent discount

suggested that no meter remain in service without re-test after the register has performed one complete cycle. Meters taken out for re-test after periods of use as great as fifteen years, show great accuracy at high rates of flow, but invariably it is found that these meters are not registering low rates. In fact, ⅝-inch meters have often been found to fail to register the flow through a ⅛-inch orifice.

As mentioned previously, sensitiveness is infinitely more important than high accuracy.

The 3-inch, 4-inch, and 6-inch meters can be easily checked for large rates of flow on site by means of a Pitometer, and with cocks inserted on both sides of the valve, the low rates can be checked by using a small test-meter between these two points with the valve closed. The smaller meters are always removed and tested in the shop. When a consumer complains of a high bill and attributes it to a meter over-registering, a test is made on site in the presence of the consumer, with portable test-meter. If the meter is once removed from the premises it is impossible to convince the consumer that the meter was right.

In the workshop all meters are tested for the higher rates of flow on a Mueller meter-tester, the amount of water passing through the meter on test being weighed. For testing $\frac{5}{8}$-inch meters for minimum and small rates of flow, a test bench has been constructed to test 9 meters in series.

Meter record cards are kept for every meter, giving the make, number, size, date received, test, cost installed, date installed, consumer's name and address, and meter reading. On the back of the card the changes and repairs are shown, giving dates, causes, tests, and cost of repairs.

METER-INSTALLING METHODS

When meters were being installed wholesale, the men, meters and other material were taken out in a Ford "light delivery" truck and a trailer, which was parked as close as possible to the center of the installation area for that day. Between 6 and 7 meters a day were installed by each man, working nine hours a day. The foreman of this gang checked all installations for workmanship and also examined the house plumbing for leaks, notifying the consumer if any were found. He makes out a card giving all the information, which is in turn entered on the office card previously referred to.

In the case of houses with no basements, or for outside hydrants, an outside meter box is installed. The box is made up of 4 feet of 15-inch glazed tile. The outer cover is of cast iron and fits snugly in an iron ring which flanges over the outside of the tile but does not project inside, thus leaving an unobstructed opening for the inner cover. The inner cover, to make the box frost proof, consists of a

wooden disc on which is nailed a piece of felt 18 inches in diameter and $\frac{5}{8}$ inch thick. When this cover is inserted in the tile, the felt is turned up around the edge of the wood, preventing the warmer air from the ground from escaping or the cold from penetrating from above. The meter is supported on galvanized iron pipe brought up to a point 18 inches below the ground level. The cost of this box with meter installation is $11.75. The consumers are charged $10 cash. The difference is an allowance for the cost of the saving of the inside installation. As most of these boxes are installed for owners of poorer houses, installments of $1 bi-monthly for two years are accepted.

With the larger variation in the number of meters handled, it is difficult to give a fair average figure for the cost of maintenance, but our records show this cost to be about 80 cents per year per meter. The figure is probably high because of an accumulation of work in recent years, and is averaged over a period of high prices.

The consumer is charged the full cost of all repairs made to a meter damaged by hot water or other causes not under the control of the department, except in the case of frozen meters, when a flat charge of $2.50 is made.

For a time the well water contained a high iron content, and deposits in the meter caused trouble. The installation of an iron-removal plant eliminated this trouble and the meters are now singularly free from deposits or corrosive action of any kind.

This paper is written more with the idea of bringing up topics for discussion than with the intention of offering advice on methods of practice. Although the water works problem is a very old one, dating back two thousand years, to the days of ancient Rome, there is an unfortunate lack of standardization as compared with that very modern public utility, electrical supply. The American Water Works Association is rendering a service of infinite value in this respect, and I am deeply indebted for the opportunity of contributing to the proceedings of the Canadian Section in a very humble way.

DISCUSSION

C. G. ROUTLEDGE: I haven't very much to add with regard to Mr. Buchanan's paper. It was a very interesting one and I am just going to make a few comparisons between the methods we adopt in Toronto and the methods adopted in London. In Toronto we

install water services to the street line only. Lead pipe is used for services ½ inch to 1 inch in diameter and is laid at a depth of 6 feet. From the street line to the building the owner constructs the service, supervised regarding material and depth by the Medical Health Department. At the street line a wiped joint is made by the owner, which occasionally is the cause of trouble afterwards. If the owner desires to avoid this joint, we leave a coil of lead pipe at the street line sufficient to reach to the building, provided the building is not a greater distance from the stop-cock than can be reached by a coil of pipe usually supplied by manufacturers. The cost of the extra pipe left at the street line is paid for by the owner when he pays for the service installation.

The installation of lead services is charged the owner on a flat-rate basis, assuming the main to be in the center of the street, but the actual cost is charged for the installation of services over 1 inch in diameter.

Galvanized iron is used for 2-inch services, and cast iron for services of larger diameter.

The location of stop cocks and valves on services is fixed by two measurements across the street, one from the curb, and one from the building, fence or street line. Two measurements are also taken longitudinally on the street, one from the line of the side of the building nearest the valve, and one from the street line of the nearest intersecting street.

These measurements, together with the size and date of installation of the service, are entered in loose-leaf ledgers alphabetically with regard to the name of the street, and numerically according to the number of the property on the street.

With regard to a service charge, I am personally in favor of it, based on the average cost of maintaining the particular size of service; also a meter service charge based on the average cost of maintaining the particular size of meter.

I am also inclined to a minimum charge for water, in order to remove the tendency of some people, when they have to pay for every drop of water registered by a meter, to deny themselves enough water for sanitary purposes and the maintenance of lawns and boulevards in decent condition.

As Mr. Buchanan has considered these points carefully, no doubt, I would like to have his views regarding them, particularly what he

considers the best way at arriving at a fair service and meter charge, and also a minimum charge for water.

With regard to meters, I have done my best to understand them and am still struggling with the problem. I am not clear what Mr. Buchanan means by a "high degree of accuracy." My conception of it is 100 per cent from a rate of a drop per minute to the capacity of the meter—no bobbing up at some point in the line and no dropping down at either end.

The performance of each make of meter with regard to the closeness it will register 100 per cent of the water passing through it at all rates of flow within the range of its capacity, both when the meter is new and during its service life-time, is, in my opinion, well worth studying.

The high points in meters are sometimes the cause of rather serious trouble between the consumer and the water works department, and the low points result in loss of revenue to the water works.

Personally I do not think that any meter should be placed on a service which at any point within its range registers more than 100 per cent.

I think it is very important that large meters should be tested at various rates up to about their capacity, both when new and after repairs, in order to make sure that they are in good working order.

In Toronto a calibrated tank of 5000 Imperial gallons capacity is used for this purpose.

C. J. PRATT: I would like to ask Mr. Buchanan what is the average life of a ½-inch meter?

F. B. GOEDIKE: Our Water Works Department is in a rather ragged state and I am going to have some time getting it into proper working order. Our charges are based on the same principle as the City of Toronto. Our mains are constructed under the Local Improvement Act and charged directly against the property. We have a ½-inch service into each house, which we charge for, after the first 20 feet from the street line. I am not familiar with the cost as that comes under the revenue department. We have installed a number of copper services. I cannot say at present just how they are working. We have in the neighborhood of 8000 meters. We are putting them on as fast as we can get them. The meters are

placed in the houses where there is no danger of frost. Where we find the amount of water used in a house is not excessive, and that it is too expensive to keep the meter there, we take the meter out. We have a number of small three and four-roomed houses that are not metered.

A. H. R. THOMAS: In New Toronto we do not meter anything at all outside of factories, therefore our proposition would not be of much interest.

THE CHAIRMAN: Are you using copper pipe or lead pipe?

A. H. R. THOMAS: We are using lead pipe, although we are thinking of changing to copper pipe owing to the expense of lead. We put in ¾-inch services.

GEO. FISHER: I feel rather out of place in making comments to this convention. As a manufacturer and also a meter user, I do believe that this is a live subject. I do not say that it is possible to eliminate the ¾-inch service, but I believe that it should be given serious thought. I would like to ask Mr. Buchanan why he uses galvanized service pipe when his lead pipe does not show any deterioration in forty years?

E. M. PROCTOR: There are a couple of points in connection with this discussion that I would like to enlarge on. We hear so often the question of the per capita consumption of water, and it varies so much from place to place. It seems to me that if somebody would figure it out and bring it down to a standard, we would get some place. With a standard pressure of 40 pounds, you will have a certain water consumption, and if you put in a pump and raise that pressure to 60 pounds, your water consumption immediately jumps. The percentage of houses that are connected directly to the sewer is a very great factor in increasing the consumption of water. A municipality will get along with thirty gallons per capita, but immediately they put in sewers it will jump up to 60, 80 or sometimes 100 gallons per capita. That is a very important factor when you are talking about the per capita consumption. I think that has a great deal to do with why the figures are different in some places.

I am very much in favor of water meters. It is not only the

saving you have in your water, and it is not altogether capital cost of the meters, but some day you may have a shortage of water. And another important matter is that if you increase your water consumption, you also increase the amount of flow that enters your sewer system. So that if you decrease the cost of the water works plant, you also make a reduction in the cost of the sewage plant.

I am very much with Mr. Buchanan in regard to water rates. I think the service charge is right, and then charge the consumer for the water he uses after that. If you have any reductions to make in the water rates, take it off the cost of the water and leave your service charge to cover your capital cost.

I think there is very little difference in the cost of the ½-inch and the ⅝-inch pipe, and the water delivered through a ⅝-inch is much much more than that delivered through a ½-inch pipe. Our standard is a ⅝-inch. I want to congratulate Mr. Buchanan on the paper he has given and the charts he has prepared. Anyone who is familiar with that kind of work knows that it represents a large amount of work and study. I hope that this paper will find its way into print so that we will have it on record.

THE CHAIRMAN: Mr. Buchanan spoke of the comparative cost of lead and copper pipe. We use 11-pound lead, and the cost of lead is 55 cents as compared with 29 cents for copper pipe, and if you buy in large quantities you can get it for 27 cents.

Mr. Proctor's remarks bring to my mind the question of what is meant by per capita consumption. There is something there on which you may be led astray. I maintain that if you are going to figure the per capita consumption of any municipality, you should first take out your commercial and industrial water. You may have a municipality where the industrial water used in a very large amount. In my own town we used to think that our industrial works could maintain a population of 30,000 inhabitants, and we only had 8000 and were depending on outside places for our labor.

E. M. PROCTOR: That is very well illustrated in New Toronto. They have a separate system for pumping water to the Goodyear plant. Their per capita consumption is quite low, because the water taken by the Goodyear plant is not included.

T. HODKINSON: You have to take the operators who are employed in the industrial plants into consideration.

G. R. JACK: In East York we get our water from Scarboro. At the present time we have only one factory using water. Up to two years ago, when we started putting in sewers, our per capita water consumption was about 16 gallons per head. After we put in the sewers it jumped to 25 gallons per head. We are still constructing sewers.

M. PEQUEGNAT: I very much appreciate Mr. Buchanan's paper for the reason that our conditions in Kitchener are similar to those at London. Their rates are slightly lower than ours, but they put in the service and we do not. With us the consumer pays for the service right from the main. We charge him a flat rate of $19 for putting in the service, whether it is on the far side or the near side of the street.

Concerning consumption: In the year 1924, our consumption was down to 52 gallons. Last year, 1925, the factories were working more and our consumption jumped to 65, but the consumption for domestic use both years was 22. The whole difference was due to the increase in industrial activities. For the last four or five years we have had these figures, and they do not vary 1 per cent on domestic consumption.

N. M. R. WILSON: Did I understand Mr. Buchanan to say that they do not meter their fire service? I have several cases where meters have been put on the fire service, and they showed that there is a considerable consumption in that way.

THE CHAIRMAN: Personally I would not allow any person to have a 6-inch service unless I knew what they were doing. I do not think it is possible to have a fire service that will stand dormant for a long time and then come into use suddenly. I will tell you an instance of where we put a fire-service meter on a plant that was newly constructed, and the first quarter they used 232,000 cubic feet through their fire-service meter. It happened not very long ago that they had a bill for $162 for water passing through the fire meter, and we discovered that a paving contractor had attached his hose to their hydrant and used their water while he was paving the street.

Personally I think the size of the service is rather a local condition. There is one viewpoint that has not been mentioned, and

that is the loss you have through brass fixtures. Members of the section who have the Water Works Manual will find a very interesting topic on loss through stops. First the main stops, the curb stops, and then the cellar stops. I have had occasion to make some tests on stops, and I found the loss equal to 30 per cent. Many of you know the old waste stops that the plumber makes on the basement wall, and these cause a great loss of water.

H. F. HUY: The question of a ½-inch service has been discussed. Changes in modern plumbing have brought it about that instead of putting in the type of closets that have been used so long, they are now getting a flush closet that will conform more or less to water works practice. I think in the past where we have been putting in ½-inch service to the ordinary one and two-family house, they should be changed to ¾-inch service. When we do that, we find we have very little trouble in the house. It has been my habit in the past to get paid for every bit of water that leaves the pumping station. We are now getting paid for 98 per cent of the water that leaves our station. The only way we have accomplished that is by careful maintenance and by metering everybody. Originally we only got paid for 45 per cent of the water at our station. We have large manufacturing plants that have six and seven miles of pipe. There is no way of checking where the superintenent will take water. Sometimes they will go up to the top of the building and run in a pipe there. We place a meter on these fire lines and we keep a record of the consumption. In nearly all our fire connections of that kind, we take a tap off immediately beyond the fire meter, and we show them that in order to keep that meter in working order that is desirable.

KEITH WEBSTER: Mr. Pratt said that we had not much of a water works system in Owen Sound. I would like to say as a commissioner of Owen Sound, and as a resident there, that we have quite a water works system. We have a gravity system and there is no pumping to do. We supply water as cheaply, if not more cheaply, than any other municipality in the province. We supply house service at 25 cents a month. If there is a bath in the house, that is $1.00 a year extra, and if there is a water closet, that is $2 a year extra. That makes $1.50 a quarter, payable in advance.

Our water works system cost $400,000, and it will belong to the water-takers when paid for. The city has never levied a dollar upon the tax-payers.

We have made provision for interest and sinking fund. The water runs down-hill. Our intake comes in at about 240 feet above the level of the town, and is carried to a reservoir that is 200 feet above the level of the town, and that gives us all the pressure we require. Our superintendent, Mr. Pratt, is not only employed in connection with the water works. He does not give the water works all his time. The city council pay part of his salary for being plumbing inspector, and he gets another allowance as building inspector.

We have over 40 miles of main on our streets and 165 hydrants. We are following the system of having valves in front of each hydrant.

Our idea is to give such a low water rate that everybody will want to take water. We charge the city $20 for each hydrant, and we charge them for flushing the streets, and so on. Our profit last year, after everything was met, was $3500. It would cost about $12,000 to meter our system, and we think that it is better to let the people waste a little water than to go to the expense of putting in meters.

THE CHAIRMAN: I think you are very fortunate in Owen Sound.

E. V. BUCHANAN: If some one will move that the banquet will be abandoned to-night, I will proceed to answer all your questions. If any of you are commissioners, and you want to be re-elected, I would advise you to leave the water rates alone.

You cannot make a comparison of water rates in different cities without first knowing the source of supply, because if you have water that runs right into your pipes, you do not have expensive pumping. Then again, you must consider whether the mains are paid for out of local improvement plan or by the municipalities. Then you must take into consideration whether the municipality pays for fire service, watering streets, and so on. There are fine points that have to be considered before you can make a comparison.

It is a very difficult matter to justify a service charge to the consumer. He thinks that when he has paid for the water going through his meters, he has paid for all he should pay. My own idea of a service charge is that first of all you should put all the fixed charges on that portion of the plant which is specifically for the use of the

consumer—the meter in the cellar, the stop-cock service, the distribution mains, and if you add all these charges together it will figure about $8 a year. Our service charge is only $6 a year. Anyone who pays less than $8 is getting service below cost, and someone else must be paying for it. I cannot get it into my head that a service charge is not correct.

Someone has asked as to the life of a meter. I think it is about twenty or twenty-five years. Of course, it all depends upon the condition of the water.

Mr. Keith asked as to water rates in London. They are $11 a year, and we do not think that is an exorbitant charge. People on a flat-rate, with a large house, who have a small consumption, secured a lower rate when the meters were put on, and in some of the smaller houses with a larger consumption the rates were raised.

In reference to the per capita consumption, the figure 1 produced shows that it works out at about 17 or 18 gallons per capita for domestic use as against a total per capita consumption of about 65 gallons last year.

A 16 per cent increase in our pressure produced a 25 per cent increase in consumption.

It is a little hard in London to justify the cost of meters against the saving at the present time. It cost about $175,000 to meter the system. It would cost about $150,000 to secure the water to supply the saving that we made. But in addition to the cost of getting the water, you have the cost of pumping and delivering it.

The day is not far off when the city of London and a great many other cities will have to enter upon a very extensive scheme for securing more water, and if you can possibly postpone that by metering the system I think it is a good investment.

J. Clark Keith: In The Journal for January, 1926, the contribution by the late Leonard Metcalf is of much interest in relation to the paper just presented. Mr. Metcalf has listed 51 American cities, and divides them into five groups ranging from those with a population of less than 25,000 to those in excess of 1,000,000. In each of the five groups he has made a study of their water consumption over a period of twelve years, in which interval their metered services increased from 83 to 96 per cent. In each group, despite the increase in metering, the consumption increased from 67 to 90 gallons per capita. His figures show that increased population results in a definite in-

crease in the per capita use of water. This increase is about 10 per cent of the increase in population.

In other words, if the population of the community doubles, one may reasonably expect to find a 10 per cent increase in the per capita use of water.

It should be noted that this refers to cities which have at least 83 per cent of their service metered. Any water works superintendent in a growing community that is 83 per cent metered, who can keep his per capita use stationary or reduce it, is securing better than average results.

A measure more effective than metering in reducing waste lies in increasing water rates. The figures show that a 100 per cent increase in water rates reduces the consumption by 40 per cent. Such a procedure to curtail waste would not meet with the approval either of the executive heads of the department or of the consumers, as increased rates could only be justified when required to cover capital and operating costs.

It would not be fair to the other elements of a water works system to say that the house services are the most important unit, but they at least constitute the main source of revenue, and as such should receive special consideration.

The depth of house services is subject entirely to climatic conditions, ranging from 4 feet in the mildest sections of Canada to 9 feet in Northern Ontario and the Prairie Provinces. In the West they are frequently frozen at that depth, and it is not unusual to see the electric thawer at work in June caring for a service which the frost had just reached. The service should be laid in its entirety from the main cock to the stop and waste within the house by the water authority of the community. Any departure from or division of this work, even with close inspection, will prove unsatisfactory from the view point of the distributor.

For ordinary house services galvanized pipe should be placed in the same class as hoop skirts, while lead pipe at present-day prices bids fair to give way to copper.

It is difficult to make any arbitrary ruling with respect to the laying of services prior or subsequent to the laying of pavements. Where it is very evident that a street is to be built up immediately under conditions of growth such as exist in the Border Cities to-day, or where the nature of the development is pre-determined through property restrictions, it would be unwise to defer the laying of services until after the pavement is laid. It should be an axiom

that all services of this character be laid well in advance of the pavement, so that there will not be subsidence at a later date. Where the mains and services are laid as a local improvement, it does not impose as serious a burden on the property-owner, when spread over a period of years, as would be the case when laid as individual service with the resultant demand for payment of the entire sum. Each street should be considered independently, the judgment of the executive head to dictate the policy.

The use of water in the City of London compares favorably with that of any city in Ontario, and the amount of water unaccounted for comes well within the legitimate limit commonly set. From information contained in the paper it is difficult to determine just what the annual bill would be to an average householder and any estimate is open to correction. At 80 gallons per day per meter or 16 gallons per capita (5 to the household), this might approximate $11.50 under the metered rate, compared with $8.10 under the previous flat rate. This represents an increase of 40 per cent, which from the findings of Mr. Metcalf, should reduce the consumption by 22 per cent.

Where flat rates have prevailed in a community for some time, it is difficult to inaugurate a policy of general metering without some opposition. With a meter rate which is equitable, it is the general experience that the metered customer pays less for adequate service than his unmetered neighbor. There cannot be any reasonable argument against the metering of water any more than there would be against the use of gas or electric meters. While not in accordance with the recommendations of the American Water Works Association, there will be less opposition to a rate which includes a definite quantity of water with the minimum charge than if there is a service charge alone.

A study of water rates in the Province of Ontario shows that those of the privately operated system of the Walkerville Water Company at 10 cents per 1000 gallons for normal domestic use are as low as any. This company furnishes 80,000 gallons of water to a metered consumer for $8 per year, which covers the service charges as well.

The City of Windsor now has the installation of meters under way, the rate as yet undetermined. In the cities of Ontario there is a very marked difference in the per capita use between those which have limited and unlimited sources of supply. The City of London, with its source of supply unlimited, has a consumption which places it definitely in the group with those whose supply is limited.

The general installation of meters is an indication that a municipality desires to reduce the consumption of water. While meters may receive the credit for the decrease when installed, there are other factors which should not be overlooked. Waste-water surveys will probably be undertaken at intervals, detector meters will be placed on mains at convenient locations, and more frequent inspections of house services between the main and the house will take place. All of these help the reputation of the meter in eliminating waste.

In the concluding paragraph of Mr. Buchanan's interesting paper, he makes a passing reference to the water supplies of Ancient Rome, and it is of interest to note that even then they were concerned with the question of water waste and illegal use. Frontinus, who was a water commissioner of Rome in 79 A.D., has left us a memorable work which has been translated into English by Clemens Herschel, the developer of the Venturi meter. We can say at least, that some progress has been made hydraulically since those days, even if there is little attempt at standardization. Frontinus computed discharge by cross-sectional area alone. He had no idea of the velocity of water either in open or closed pipes. The well-known formula, $v = \sqrt{2gh}$, was not known until 16 centuries had passed. A square foot of area, whether in a stream or conduit or composed of the sum total of 200 or more pipes discharging at different elevations, was considered the same in value.

From the cisterns or tanks which received the water from the various aqueducts entering the city, the water was distributed in lead pipes up to 27 inches in diameter, the joints of which were soldered with pure lead. From inscriptions on these pipes, much of the work was done by female plumbers, but it is not recorded whether the female plumber of those days was any more efficient than the male plumber of today. They had their four-way branches, brass stopcocks, wiped joints, bronze bath tubs, and devices for measuring water in a crude way. A flat sheet of lead just under 4 inches long was rolled into a cylinder and this became the standard orifice measurement. On the end of this the water user was compelled to have a length of pipe 50 feet long of the same diameter. He could then expand it or do as he pleased. Evidently Frontinus had some idea of the friction loss in pipes, and to prevent these from becoming plugged, small traps were provided at intervals to catch the pebbles which came through the aqueducts. In many cases these orifices were made larger than the amount set forth in the grant from Caesar, and after systematically checking all water uses, Frontinus states that the finding of the sources of illegal use practically doubled the quantity available and was equivalent to finding new sources of supply. Thus may he be considered one of the pioneers in the attempt to reduce water waste.

THE POLLUTION OF WATER SUPPLIES BY WASTES FROM CANNERIES AND DAIRIES IN IOWA[1]

By J. H. Buchanan[2]

During the past few years there has been a very noticeable and steady increase in the output of Iowa canneries and creameries. This has been due in part to the construction and operation of new plants and in part to the enlargement of already existing factories. This increase in output has meant, of course, a considerable increase in the manufacturing waste, of which proper disposal should be made.

In normal seasons, and with the smaller manufacturing plants in operation, the problem of stream pollution has not seemed to be very serious. But with the centralization that is taking place, particularly in the corn canning industry, and in the dairies, the problem has become more serious. Particularly has this been true during the season that has just passed, when the water supplies of the streams had just been diminished to a considerable degree. In the past season there have been instances in which the streams into which our factory wastes have been discharged, have not carried sufficient water to furnish the proper dilution. In other words, the subsequent purification of this water for domestic use would be increasingly difficult, to say nothing about the nuisance that would develop.

Stream pollution is important to those interested in water supplies because of the difficulties arising in the purification of water from streams into which these trade wastes have been emptied. Corn cannery and creamery wastes differ from domestic sewage in that they contain undesirable amounts of carbohydrate, which in fermentation markedly increase the acidity of streams into which they are discharged. This acidity may be such as to render the water corrosive to water mains.

In order to emphasize this matter, two typical sets of analyses

[1] Presented before the Iowa Section meeting December 3, 1925.

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will be considered. Table 1 shows the effect of corn cannery waste on the stream into which this waste was discharged. The samples analyzed were as follows:

1. Composite sample of the waste collected hourly during a day's run of the plant.

TABLE 1

Effect of corn cannery wastes on stream

Results expressed in parts per million

	COMPOSITE SAMPLE	CREEK BELOW PLANT OUTLET	CREEK ABOVE PLANT OUTLET
Solids:			
Total	1860	860	528
Dissolved	1600	820	480
Suspended	260	40	48*
Nitrogen:			
Ammonia	1.5	0.85	0.025
Organic nitrogen	28.5	11.15	1.00
Oxygen consumed:			
Total	746	145	51
Dissolved	490	142	48
Suspended	256	3	3
H+ ion concentration (pH):			
Initial	7.7†	5.6	7.4
After 2 days	5.1		7.5
Biochemical oxygen demand:			
3 days	320	250	42
5 days	515	370	60‡

* Sample collected when water was low. There was evidence of mud contamination.

† Reaction after boiling. Before heating value was 6.6.

‡ Estimated from three day result.

2. Water from the stream above the outlet of the plant waste.

3. Water from the creek taken one-half mile below the outlet of the plant waste.

While the results from these analyses would indicate that the stream was polluted before the factory waste was admitted, the possibility of contamination while taking the sample must be considered. The admittance of small amounts of bottom mud into

the sample accounts for the high oxygen consumed and oxygen demand values of the stream water.

An inspection of table 1 brings out the fact that the stream has been seriously polluted with factory waste. The total solids of the plant waste are about 3.5 times that of the stream before pollution. An increase of 332 parts per million is noted at the point where the sample was taken below the plant outlet. It is also interesting to note that the increase in total solids in the stream water is due almost entirely to dissolved solids. This indicates of course that the suspended solids had been removed by settling in the half mile interval between the plant outlet and the point at which the sample was taken. This waste from the corn cannery would tend, therefore, to produce unsightly deposits, and furthermore would be subject to fermentation with the production of acid and disagreeable odors.

A study of the nitrogen values also shows the extent to which pollution occurred. An appreciable increase is noted in the stream water below the outlet, both with regard to the free ammonia and total organic nitrogen. A dilution not to exceed 1 to 4 is indicated, which dilution must be considered inadequate. In this calculation no account is taken of the chemical changes that may have taken place between the outlet of the plant and the point where the sample was secured.

The values for oxygen consumed indicate a waste about ten times as strong as domestic sewage. The high value for the suspended material brings out the same point mentioned with regard to the solids, that a great deal of good would be accomplished by removing the suspended solids. This determination, essentially a measure of the carbonaceous material present, shows the large amount of organic matter present that would be subject to fermentation.

The biochemical oxygen demand may be employed as a measure of the oxygen required to prevent the decomposition of sewage with the production of objectionable odors. Stream water ordinarily carries from five to eight parts per million of free oxygen. The high oxygen demand of the sample below the outlet points to the fact that there would be a definite depletion of the oxygen in the stream. This would result not only in the production of objectionable odors, but also in death of the wild life of the stream.

The acid production in the plant waste is a measure of the fermentation that is taking place. The sample of waste gave a pH value of 6.6. After boiling the value changed to 7.7 which indicates less

acidity due to the volatilization of acids formed in the fermentation. After two days of storage the boiled sample, inoculated with Bact. coli, developed acidity to the extent of pH 5.1, or in other words, the sample had become one hundred times as acid. The fact that a pH of 7.4 was obtained on the creek water above the point of the plant outlet and that below this point a pH of 5.6 was obtained, shows that in spite of the dilution with creek water the acidity had been increased nearly one hundred times.

This increase in acidity would be of extreme importance when considering the stream as a source of water supply. The corrosive effects on the pipes with which the water would come in contact would be serious. There would be difficulties in purification of the water due to the increased hydrogen ion concentration. This would be particularly true where some of the chemical methods of purification were used, because of the fact that this acidity would need to be neutralized before the process of purification would function properly.

In considering stream pollution due to creamery wastes no table of actual analyses will be given. An examination of a number of composite samples of creamery waste, collected every 30 minutes for an entire day's run, showed that they contained sufficient milk to correspond to from 1 to 5 per cent skim milk, with an average strength equivalent to about 1.5 per cent skim milk. The average Iowa creamery waste would show the following analysis:

	pp.m.
Organic nitrogen	35–45
Oxygen consumed	600–750
Biochemical oxygen demand	750–900

It is evident that a considerable load would be placed on a stream attempting to care for a creamery waste, figured on the basis of 1.5 per cent skim milk. Creamery wastes, as those from corn canneries, contain undesirable amounts of sugar and will quickly sour, increasing the acidity of the streams into which they are discharged. Ordinarily in problems of stream pollution the interest lies in the question of oxygen depletion, but, with the wastes in question, the effect on the acidity of the stream is of particular interest to the water works operator.

SUPPLY, INTAKES AND STORAGE[1]

By William Gore[2]

In the Manual of Water Works Practice recently issued by the American Water Works Association, the first six chapters deal in an excellent way with the subject of this paper. It is not the intention of the author to attempt to summarize the matter contained in these chapters, but rather to place before you the result of his thirty-five years' practical experience in all phases relating to water supply and sewage-disposal, and the bearing the one has on the other on the selection of a suitable source of water supply for any community. While the laws of nature are the same in all parts of the world, the climatic and physical conditions and the governing laws are different, so that here in Ontario we must of necessity have our own particular method of approaching the problem, and this is the reason that this article is not a summary of the Manual, but rather the result of personal experience.

All water used for public service earlier or later is derived from the clouds by precipitation as rain or in frozen form principally as snow. This precipitation varies from place to place and from time to time in any one locality so that its incidence is a problem in each situation (of climatic conditions and probabilities) based on the assumption that its variations in the past will continue into the future. Many observers have endeavored to discover cycles of change in periods of years, and cycles within cycles over centuries, but after all it may be stated authoritatively in this regard that the day that is past never returns again, so that we may regard the incidence of rainfall and the flow of a water-course, a spring or a well resulting therefrom, as one of pure chance, with limitations. Not that we regard the world as being governed by chance, but that the factors that enter into this problem are so numerous and varied in their amplitudes that they become too intricate for normal evaluation and recourse must be had to statistical probabilities.

[1] Presented before the Canadian Section meeting, March 3, 1926.

[2] Consulting Engineer, Toronto, Canada.

NATURAL STORAGE OF WATER

The water that is not lost by evaporation or absorption by percolation is collected into streams or rivers. It may be stored for use in reservoirs or lakes and in the crevices of rocks and soils and then be made available for use either directly by gravity or by pumping with or without the expedient of sinking wells and adits driven into the water-bearing rocks. Thus we have two great divisions in the sources of water-surface supplies and underground supplies.

In the Province of Ontario at the end of 1924 there were 205 municipally owned systems of water supply and 8 privately owned systems. Surface supplies numbered 133 and underground supplies 76, while combined or unknown sources of supply numbered 4, so that the number of surface supplies are almost double those from underground sources. The total amount of water derived from surface supplies forms the bulk of the whole, and is therefore far and away the more important. The dependence of water supplies upon rainfall is somewhat marked in the neighborhood of the Great Lakes System which stores up vast quantities of water which are discharged from the outlets of the lakes at a nearly uniform rate, the minimum flow at any time being hundreds of times greater than the needs of the population along the shores, and this source is therefore almost unlimited.

Where the dimensions of the stream get less and less in relation to the population depending upon it for water, some estimate has to be made of the amount that is or can be made available at all times from it. Obviously the period to consider is that in which the flow of the stream is at a minimum. This occurs in times of drought when the weather is dry and warm, and when the demand for water is greatest. Frost may also cause the streams to dry up, particularly when they are either small or in a northern district, and the demand at this time may also increase because of the running of taps to avoid freezing.

A long period of continuous record of the flow of a stream is desirable in order to determine the amount of water that can be secured from it either directly by the daily records, or, if a reservoir is needed, to tide over the low flows and high demands by plotting mass curves.

STUDY OF RAINFALL STATISTICS

Generally speaking the stream records are not available and when this occurs a hypothetical mass curve must be prepared. This can

only be done after a very close study of the rainfall statistics of the district and stream flow statistics from other comparative sources. Such estimation must be regarded as the work of high specialization and cannot be gone into at length here, but a typical example is worked out and the general results are as follows:

1. Only a proportion of the rainfall is available as stream flow and this proportion varies over wide limits from place to place. The actual loss in this vicinity may be as much as 20 inches per annum reckoned over the whole drainage area.

2. The minimum flow of a stream may be nil and frequently less than 10 per cent of the average, and the maximum flow may be many times as great in the absence of lakes, reservoirs or vast areas of porous materials to modify the flows.

3. The effect of reservoir capacity in balancing the irregularities of supply and demand is most pronounced at small demands and reservoir capacities relative to the flow of the stream.

4. It is generally regarded in the typical case that not more than 80 per cent of the flow of a stream can be economically secured by the use of reservoirs upon it. This may be obtained when the storage amounts to about six months' supply. Such reservoirs are usually formed by constructing dams across the streams. These invariably form engineering works of the first magnitude and their development has taken place over a long period, occasionally attended with serious failures involving great destruction of life and property. Much thought and study have therefore been given to every phase of this problem, both from a practical and theoretical viewpoint. It may be said, however, that almost every failure has been due to a disregard of the practical requirements of the situation; that is to say, to attempted economy, incompetence and inexperience.

RIGHTS OF RIPARIAN OWNER

The right to take water from any stream for water supply purposes has not been well established in Ontario from the legal standpoint, owing, no doubt, to an abundance of water and the absence of powerful riparian owners interested in maintaining the flows of the streams unimpaired. The right of a riparian owner is that of a user only and is founded on the common law of England, briefly stated as follows:

Any unauthorized interference with or use of water to the prejudice of one entitled to its use is the subject of an action for damages.

He has the right to have it (the water) come to him in its natural state in flow, quantity and quality and to go from him without obstruction.

Thus to divert water from its natural source can only be legally met by compensating in some form or other the riparian owner. The demands of a municipality are of course insistent and the riparian owner must make way for such diversions. His interests have usually in Great Britain been met by securing for him a fixed proportion of the flow of the stream augmented in dry periods from water stored in reservoirs built by the diverting authority.

In any actual stream of water there is an inevitable mixture of surface and underground waters, because all drainage areas have a proportion of porous materials thereon into which the precipitation penetrates, some portion being returned to the atmosphere and other portions given out as springs which feed the stream at times when the rain ceases. The water that enters into the porous materials dissolves them and so alters to a considerable extent the character of the water. It may be hardened by calcium and magnesium compounds, which up to a limit is desirable. It is found that about 60 parts per million of hardening constituents are desirable in a domestic water. The water may be stained by juices primarily of organic origin and also become acid so as to attack lead service pipes. It may collect iron and manganese. These features are objectionable, and if considerable, the water will require special treatment by purification processes.

Most watershed and gathering grounds are subject to the possibility of contamination by animals and human beings as well as by developed industries. The Public Health Act, 1914, gives the Provincial Board of Health of Ontario full power to protect the source of any public water supply within its jurisdiction and a penalty of $100 may be incurred for each offence. The exercise of this power to the full would have introduced serious difficulties of an economic nature, particularly along the Great Lakes System, where much of the contamination comes from sources outside the province and a considerable degree of toleration has been permitted. In order to meet this situation, water has been and is being used for domestic purposes which contains a degree of pollution, and it becomes a matter of grave consideration as to how much pollution can be allowed in the source of a water supply without endangering the health or outraging the tastes of the community. This, of course,

depends upon the purification processes available for treating the water before it reaches the consumer.

POLLUTION IN GREAT LAKES SYSTEM

The International Joint Commission on the Pollution of Boundary Waters has stated that the limit which purification processes can meet with boundary waters is reached when B. coli are positive in 50 per cent of the 0.1 cc. samples carried out over a period of at least a year.

This standard has been accepted with certain reservations in the Manual of Water Works Practice.

It has been shown that in the Great Lakes System there are practically no points at which water can be secured free from pollution. In a general way this pollution hugs the shore in the neighborhood of the cities, it being blown hither and thither, becoming more diluted as time proceeds, and by natural processes the pollution ultimately becomes dissipated. This of course applies to all waters in contact with the atmosphere, from which the necessary oxygen is obtained for this process described as self-purification. In the meantime there is the possibility of considerable intermittent pollution at any water works intake in the vicinity due to these wind-driven currents, which require constant vigilance on the part of the water-purification authorities.

A municipal authority is responsible legally in the case of negligence, and morally at all times, for the quality of the water delivered to its people.

Very serious situations have arisen owing to specially objectionable matter gaining access to the water supply, and which is made evident by the formation (with the chlorine used as a sterilizing agent) of chlorophenols and chlorocresols or other products giving the water objectionable tastes and odors. This is a matter which is having the attention of the health authorities, and the practical solution for overcoming these tastes is close at hand. Tastes and odors in water may also be derived from decaying vegetation and algae growths requiring treatment by copper sulphate or by aeration as well as by the usual filtration and chlorination processes.

During the break-up of the winter conditions and prolonged wind storms, most streams and lake fronts used as water supplies are subject to considerable turbidities as well as pollution, and these produce difficulties in the supply of a pure and sparkling water which

can only be dealt with by purification plants of sufficient capacity to meet the situation.

SITES FOR INTAKES

The sites for intakes in the waters or rivers or lakes demand much care in their selection in order to avoid as much as possible transient pollutions or turbidities which hug the shores, bottoms and surfaces. The intake mouths must be so large that the intake velocities are small, and of such form as to avoid vortices which may draw in air or ice. To avoid the latter, large covers are sometimes placed over upturned wide bell mouths with entirely satisfactory results. The intake in a river should not introduce large disturbances in the current, which would cause erosions, nor tend to the formation of frazil ice, nor should they obstruct shipping unless permanent structures are provided, manned and controlled like a lighthouse. These are expensive to maintain and absolute isolation is occasioned at times. Many instances are on record of intake pipes being broken on the occasion of wind storms, so that it becomes desirable where possible to drive intakes at a low level or in such strata that their safety is definitely secured. Where this is not possible or desirable, considerable protection can be secured by sheet piling, but any interference with the natural underwater surfaces produces a chain of indirect changes difficult to follow or to provide for.

WATER FROM UNDERGROUND SOURCES

These are derived from springs, driven wells, adits, collecting galleries and bore holes. These waters differ from surface waters generally in their considerable content of dissolved mineral matters and their freedom from pollution or turbidity. Thus the principal treatment to make these waters potable is their demineralization by means of softening, rather than the removal of disease germs. But experience has shown that these underground waters are peculiarly susceptible to contamination on exposure, and the records show dire results from neglecting the necessary precautions. Disease germs have been known to travel underground for miles and cause infectious diseases afterwards. However, springs and wells from time immemorial have been regarded as among man's greatest blessings and are likewise so regarded by Scriptural precept, and it is little wonder, for in the semi-arid regions where the Scriptures were written the very life of the people and their flocks were dependent upon

such wells. Springs or wells of water are in our own civilization looked on with favor for direct drinking, owing to their palatability, sparkling clarity and coolness.

In certain other cases medicinal properties have been discovered, and mineral baths are prescribed for certain ailments. We have even at this age our sacred pools where cures are frequently recorded. Such waters may have been locked up for ages in the interstices of the rocks and have become highly mineralized and very seldom come within the province of the water works engineer. They are small in quantity, but exceedingly important in the Spas and Bads of the ancient world. Waters containing sulphuretted hydrogen or iron carbonate are specially sought after. The one as an aperient and the other a tonic.

Any public authority depending upon underground sources must have reasonable assurance of the quantity available, as determined by gauging in the case of a spring, and from the rainfall and percolating area and pumping records in the case of a well, and even then a well is a precarious undertaking, and many have been the disappointments both as to quantity and quality, but in spite of these the public generally believe there are great quantities of untapped suitable water available. Perhaps the experience at London, England, accounts for this belief, as there many millions of gallons of water are daily delivered to the city from such sources, but the situation is exceptional, and even here the saturation level has been falling for many years about 1 foot per annum, showing that the stock is being absorbed, not an unusual experience with well waters.

Such is the precarious nature in most places depending upon a run for fortuitous circumstances, that well-sinking should not be resorted to for a public water supply unless a satisfactory surface supply is not available. Spring flows are exceedingly variable and may dry up altogether either by a deficiency of rainfall or another outlet being found. The spring, however, can be dealt with by gaugings and statistical probabilities and can be considerably augmented by reservoirs, which should be covered to prevent algoid growths, to which these waters are peculiarly susceptible.

Most driven wells depend upon the fortuitous circumstance of striking a faulting plane or back or crevice, as the movement of water in so-called water-bearing rocks is generally exceedingly slow. In some of the important wells there are many miles of collecting galleries which have struck a crevice here or there and generally the supply has come partly from stock.

Underground waters may be found in sands and gravels, in sandstones and limestones and to a less extent in other materials. The limestones are specially interesting in this respect as they are soluble in rain water, which becomes hardened thereby, and large underground rivers and caverns are formed, like the system of the Kentucky caves. Such caves and underground water courses are truly wonderful, but the searching for the latter amidst the caves may not be rewarded.

Sometimes a well, after yielding good water for many years, has suddenly become brackish. The explanation afforded is that the well was dependent for many years partly upon the surface percolation and partly from sea water or from deep-seated salt water which has been satisfactorily treated by means of the natural zeolites in the bedded materials. When these materials become used up, the well becomes brackish.

The movement of water in open sands and gravels is generally understood. The flow towards a well is dependent directly on the slope of the saturation surface and the area of flow, and inversely as the specific surface area of the materials. The surface of saturation in the vicinity of a well in sand being pumped is approximately a logarithmic surface of revolution but is usually described as a cone of depression. This cone of depression in open materials has been observed to extend to great distances. Where such does take place, one well affects the yield of another. The common law gives no protection whatever, and instances have been noted where well sinking has proceeded in two wells by two authorities, one against the other. Instances are known where a well is so free that tidal phenomena has been observed in it.

Water supplies have been sought by excavating large so-called filtering basins in the sands and gravels by the side of large bodies of water. These often at the beginning have a good yield, which gradually falls owing partly to depletion of stock and partly to the pores of the source becoming choked.

Sometimes water-bearing strata are shut down underneath impervious materials which themselves are depressed below the surface levels of the water-bearing materials at some more or less distant point. Boreholes sunk through the impervious materials in the depression to the water-bearing materials will enable the water to flow freely to the surface, and such wells are called artesian.

The subject of this paper has been treated in a very general way,

with the object of bringing out the main underlying features that are considered essential in the selection of a suitable source for a water supply. No attempt has been made to enter into construction details, particularly such details as are connected with intake works. Each source of supply has to be considered on its merits.

When I went into your excellent exhibition room, my attention was drawn to a pamphlet on the cover of which was written, "What is water?" The professor under whom I was taught chemistry was a great authority on matters of chemistry, and he always used to write it down H_2O+, although he recognized that the chemical formula was two atoms of hydrogen and one of oxygen. Yet all the water we had to deal with contained other substances; if it had not these other substances in it, it was no good to use. So we are dealing with H_2O+. Mr. Brown in opening the meeting said he regards water as a commodity. I do not. He talks of water as so much material sold for cents. In my view of it the cents are for service. It is the cost of the service—taking water from one spot and pumping it up by pressure, and delivering it through pipes to a certain place.

The ownership in water is that of user only, not an exclusive ownership. That is the reason there is so much trouble about Chicago. The people of Chicago have acted as if they owned that water. They do not own the water. Their right is just that of user, and they have to use it so that anyone else having certain rights in it will not be injured. The whole world has certain rights in it.

If we had to depend on the gaugings of streams to tell how much water might be obtained, at least 90 per cent of our water works would never have been constructed. When an engineer goes on the job he has to plan his water works not within a certain period of years, but then and there. He cannot wait to set gauges for himself to run over a period to twenty or thirty years, and he must of necessity use rainfall as a basis.

There is no order about rainfall. It is pure chance. There may be dry years and wet years, but you cannot take seven wet years and say they will be followed by seven dry years and thus get an average in fourteen years. It takes say one hundred years to get a true average with a high probability of covering all variations likely to occur. Stream records and rainfall records are a problem, and chance, but as a rule the theoretical chance fits the fact, and this chart shows definitely that it is a pure chance beyond all question. The

rain gauges, together with the experience we have had with other water works shows how to deal with the problem satisfactorily.

Here is a slide showing the intakes in the Detroit River and vicinity. The little village of Tecumseh takes its water from Lake St. Clair. Highland Park, near the center of Detroit, in which is situated the Ford Works, gets its water out in the lake, and pumps it to a reservoir and filtration plant. Detroit has its intake in the river at the head of Belle Isle. Detroit is now putting in a new supply. Their present supply has a maximum of 320,000,000 U.S. gallons, and they are putting in another intake to increase that supply to 500,000,000.

Next comes the intake of the Border Essex Utilities Commission. Then a little lower down Mr. Brown gets his supply for the town of Walkerville, and a little lower still is the Windsor intake. The Essex Border Utilities Commission has constructed a sewer to collect a large portion of the sewage and discharge it into the river below the intake of the Water Commission. On the Detroit side I do not think they have a sewage-purification plant of any sort. Their sewage is discharged into the river and flotsam is often observed from the sewage discharge from the Detroit plant coming right across the river. Water supplies in the vicinity of a river like that can only be obtained by going up the river above the point of serious contamination.

DISCUSSION

T. J. LAFRENIERE: I wish to congratulate Mr. Gore on his very able survey of the various sources of water supply. There is one point that I would like to stress, and it is the necessity for water to contain something besides H_2O. I have in mind the case of one town which is using a very poor water supply. This water contains practically no coloring, and a very small amount of organic matter. The alkalinity runs around six parts per million. This water, as you can see, is almost distilled water, yet the steel pipe which is used to bring the water to city has been very badly corroded. This is a nasty situation, because the town is claiming damages from the contractor. I would like to ask Mr. Gore if he has had any cases of corrosion where the water is pure, chemically speaking.

R. O. WYNNE-ROBERTS: We have listened to a very excellent paper and it will be of great value to us.

As Mr. Gore admits, it is a general discussion on the subject, and therefore does not raise many points of controversy.

No community can exist without water, hence it is that in arid countries, springs and wells and seasonal streams are regarded with almost religious reveration. It needs but a visit to such a district to appreciate the value of a spring of cool water, and the great difference in the social life between places which depend upon distilled water like Aden, and Toronto, which enjoys the bountiful supply from the Great Lakes. Between these limits there are countless examples of water supplies both visible and underground.

Whilst it is acknowledged by us that water supplies are derived from rainfall, it is interesting to hear some people insist that some underground supplies are fed from the lakes, notwithstanding that during the past ages the lake bottoms have been made practically impervious by deposits of comminuted material.

Visible water supplies, such as from streams and springs, are always attractive sources, and with careful conservation they are satisfactory within the limits of their capacity, and subject to preservation from contamination. Self-purification of streams and lakes is a matter which requires much consideration. Polluted waters pouring over the Niagara Falls do not become self-purified until diffused in the lake below.

The building up of mass curves to ascertain the yield from streams and the storage required to equalize the flow, can be depended upon in proportion to the accuracy of the data available. But to depend on such curves to estimate by analogy what may be the yield of a neighboring stream, is a method to be applied with great discrimination.

In the absence of authentic records of stream flows and rainfall on a particular catchment area, the engineer is obliged to adopt analogy as a means of computing the estimated yield. Formulae to ascertain the approximate run-off will often serve as a guide. The yield during driest years must fundamentally be the basis of estimated supply, and whilst there are no periodical recurrences of similar meteorological conditions, it is necessary to study the record very carefully.

In the St. Catharines district the three driest years on record may be 1870–1–2, when the average rainfall was about 30 inches per year. The next three driest years were 1905–6–7, when the average was 32.2 inches per annum; and the mean of all years is about 35 inches.

Mr. Gore estimates that about 20 inches of rainfall is lost by evaporation, floods and so on. This is presumed to be the mean, and if so, in dry years it will be more. So in this district the yield per square mile will be less than 400,000 gallons per day, assuming that ample storage is provided. The popular conception that a forest induces rainfall is not proven by records, but forests, however, are great conservers of water.

The color of water is important if only from a sentimental viewpoint. Capetown water has a deep brown tint, which stains baths, etc.

With regard to underground water, it may be said that in many localities it is the only available source. The location of wells is often by no means a simple matter, but it is possible by persistent exploration to strike water-bearing strata. Even in districts where the geology is fairly well known, the drilling for good water is often a perplexing matter, and in complex glacial deposits the problem is more involved. But by careful study of the substrata and of the records of any existing wells it is possible to simplify the exploration for water.

The question of how much water it is possible to obtain from wells is another problem which involves much investigation.

Incidentally it is useful to consider the many opportunities for developing our knowledge of underground strata, through the organized preservation of the logs of drilled wells. These exist in a few districts where wells have not been sunk, but the recording of the data thus obtained is generally lost. A step was taken two years ago by the Ontario Government to have all such information recorded in the official archives for future reference, and to enable the geologists and others to build up reliable cross-sections of the country, but the Legislature would not sanction such a step.

Mr. Gore's paper certainly affords abundant scope for discussion as to future elaboration of information for the use of engineers and the public in general.

E. V. BUCHANAN: I was very much pleased with Mr. Gore's very able paper. I contend that Mr. Gore wrongly condemns an underground supply.

MR. GORE: I did not condemn any underground supplies.

E. V. BUCHANAN: In London we have had an underground supply for about fifty years, and I know the trials and tribulations an engineer has to go through in finding a further source of that kind. Running a water works department is not altogether engineering, it is partly political. If people have been used to drinking cool and sparkling waters, and if there is a river running by their doors that stinks to high heaven, and if you tell them you are going to give them river water, the engineer will lose his job.

The problem as we see it in London is this: At the present time we have a sufficient underground supply. We can get other underground supplies that will enable us to supply the city for a number of years to come, and so long as the total cost of developing this supply is less than the annual interest charges on the lake supply which would have to be piped for 45 miles, nothing is being lost and everything is being gained by using underground water.

The problem of knowing where to drill wells is a difficult one. Mr. Wynne-Roberts has said that it is a pity that logs are not kept of wells. Such information would be very useful. We have gone through the country talking to farmers and well-drillers, but we have been unable in that way to obtain approximate data regarding wells in all places, but we have tabulated information obtained and taken levels which have produced very interesting information and have enabled us to obtain further sources of supply.

MR. GORE: Mr. Buchanan must have misunderstood my remarks. In any case the getting of water supply is a question of expediency. It would hardly be possible for me to think that because the water flows on the surface in a sewer that it is more suitable than a spring of clear, pure water. No, I do not regard it in that way. In fact I ought to say that the low flows of a stream are spring water. There is no river that has not spring water in it. What I wish to demonstrate is that in searching for underground waters by means of wells or borings you are dealing largely with an unknown quantity, and if you have two sources equally suitable, measure them up in what way you like, using every factor, even the political if you like, and then, if you have two sources equally satisfactory, I would choose the surface one, because then you know what you are getting and in an underground source you do not.

These works have to be designed beforehand. You have to go to your cities and see where you can get a supply. Even if it is the

digging of a well, every engineer who has had experience in well-digging knows the uncertainty. I know cities that under the advice of their engineers have sunk wells and have had to abandon them. There are very few cases that I do know of where you have the rain gauges and the stream that you cannot tell beforehand that there is a supply, if the quality is satisfactory.

E. V. BUCHANAN: During seventeen years of weekly tests from the wells at London, they have never shown any trace of colon bacilli.

MR. GORE: That is one of the excellent qualities of underground supplies. They are usually pure and palatable. Even in my own household I use well water because I like it for drinking. I have had to go to all sources I could get, and I found it exceedingly difficult to get information as to an underground supply. It has been said that well-diggers should supply the Government with the information, but if you go to the owner of a well and ask for the information, he will say: "Bill So-and-so has the information," and you go to Bill and he will say that the Government has the information. You go to the Government and they say, "No, Bill has the information, and we will make him supply it." But I find that I cannot get the information, although I want it.

The question of water attacking steel is a very difficult problem. I remember the case of the Coolgardie water line, which was 350 odd miles long, and was used to supply water for the Coolgardie gold-mine district. That pipe showed serious corrosion. Sir Wm. Ramsay and my own firm were called on to investigate the cause. The chemists were not able to say why that particular water had extreme corrosive influences. One chemist suspected the presence of carbon-dioxide in abundance. They tested it and found it normal.

It may be that pH enters into it. This investigation did show that oxygen was the main factor as a depolarizing agent in the presence of electric current and deoxygenating the water was advised, but not accepted.

Three grains of calcium carbonate per gallon were added to the water but the corrosion continued as before. But since I have been in Canada I have read an article saying that the deoxygenizing process had been in operation for some years with marked success.

It is believed that hard water deposits a film of calcium carbonate

on the plates, which acts as an obliterating agent by which the water cannot get through to the pipes. This question of corrosion is a big matter.

I would like to say that water is very unique in nature. There are many gasses and solids, but there is practically only one fluid. The chairman says that anyone would prefer a gallon of water to a gallon of alcohol. I certainly vote for the gallon of water.

R. H. STARR: Do you not think that now would be a good time for the Canadian Section of the American Water Works Association to put themselves on record as being in favor of reforestation? Not on the small scale that is being carried on. If we cut down an acre of forest, it surely ought to be replaced by more than an acre to take care of our increase in population. If we could take care of reforestation we could take care of our rainfall in the spring, and get a more uniform stream flow and a more uniform water supply.

THE CHAIRMAN: That matter will be referred to the committee on resolutions. I am sure you gentlemen have all been intensely interested in Mr. Gore's paper and the discussion which has taken place and the explanations which he has made.

IMPROVEMENTS TO THE WATER SUPPLY OF WINNER, SOUTH DAKOTA[1]

By Geo. T. Prince[2]

The city of Winner, South Dakota, is located in a district in which it is difficult to obtain water in large amounts sufficient for public water supplies. Such water as is obtainable is to be found underground. The sub-soil generally is of a very fine sandy nature that makes it difficult to obtain the water because of the packing and encrusting nature of the fine sand sub-soil about the strainers employed with the tubular wells.

The city has in the past been depending upon water for its public needs obtained principally from two 24-inch Kelly wells sunk to a depth of about 28 feet and reinforced by about 15 wells of 6-inch tubular type that were sunk approximately 28 feet. All of these wells are connected to an 8-inch water main that was laid at a depth of approximately 8 feet below the surface of the ground.

This well system is located about 8½ miles south of Winner on ground about 80 feet above the elevation of two circular concrete reservoirs that are located about one mile south of the center of the town, and that afford a static pressure in the business section of about 60 pounds per square inch. The connecting pipe between the reservoirs and the aforesaid well system is an 8-inch machine banded wooden pipe.

There are no authentic records indicating the amount of water used in Winner, which has a population of approximately 2500. The nearest estimate would indicate from 100,000 to 125,000 gallons per 24 hours. This amount of water has had to be pumped in recent years from the two 24-inch Kelly wells, the fifteen smaller tubular wells having Cook strainers have not afforded any water, as the sand bed from which the water is obtained is very fine, the coarsest being about like granulated sugar. This sand has become encased around the screens to such an extent that the tubular wells have practically been useless for some years.

[1]Presented before the Iowa Section meeting, November 8, 1924.

[2]Consulting Engineer, Omaha, Nebraska.

Because of a shortage of water the city authorities employed a number of engineers to submit reports upon ways and means to increase the amount of water for public purposes. The speaker submitted tentative plans for obtaining the desired additional water supply, which were finally adopted and approved by the Council. A contract was effected between the city and an Omaha contracting firm based upon the following plan of procedure:

It was believed that the fineness of the sand subsoil precluded the use of open jointed or perforated underground pipe lines or even cribbing. In place of employing such a type of construction, it was decided to adopt that of an open trench which was to be excavated across the draw in which the aforesaid wells were located. This draw is about 500 feet in width and experience indicates that a large portion of the drainage from 20 square miles located above and to the south of the said system of wells passes as under-flow below the draw in which the wells are located and about 15 to 25 feet below the ground level.

The adopted plans considered excavating a trench across this draw having a width of 6 feet inside and a depth of about 15 feet below ground level. The said trench was to be sheathed with 4-inch thickness of sheathing plank that was made by nailing together two 2-inch planks, the planks being so lapped as to leave at least 6 inches. The two planks thus nailed together for their entire length with their 6-inch lap formed a couple, and contiguous couples on either side made it possible to make tight work, each couple lapping the companion by 6 inches. These planks nailed together in couples were first sunk by water jet to the required depth. The sheathing forming the upper or south line of trench was sunk to a depth of 18 feet below ground level or 3 feet below the bottom of the trench when excavated. Those forming the lower or north side of the trench were sunk approximately 22 feet below ground level or about 7 feet below the bottom of the trench as excavated, thus forming a submerged timber cut-off against the passage of water.

The trench was afterwards excavated as stated to a depth of about 15 feet below ground level, the sides of the trench being firmly braced by longitudinal and transverse members as the excavation proceeded, said bracing being spaced from 3 to 4 feet apart vertically.

The purpose of making this trench 6 feet in width was primarily to make it possible to sink Kelly wells to a depth below the bottom

of the trench should it develop that such a measure would be necessary to secure the desired amount of water.

The sheathing planks at the east end of the trench for a distance of 10 feet were sunk to a depth of 24 feet below ground level. The reason for sinking the plank sheathing deeper at the east end was to provide a sand pocket into which sand that might be held in suspension in the water would be deposited before entering the outlet pipe, which is connected with said sand pocket at an elevation approximately 15 feet below ground level.

The tops of all sheathing plank were sunk to a depth of 2 feet below ground level and furnish a support upon which was placed a 6-inch steel reinforced concrete cover that extends for the full length and width of the collecting gallery. The gallery is 300 feet long.

Five manholes have been constructed of concrete which extend above the concrete cover to ground level upon which iron frames and covers have been placed to afford means of entering the gallery should occasion require for inspection and possible removal of sand.

Over the concrete slab there has been placed earth filling to an elevation slightly above ground level to allow for settling. This earth filling has a 6-inch topping of black soil and will be seeded so that the gallery will be covered by grass sod and present a smooth surface with the surrounding field.

The water level in the gallery when no water is being drawn stands approximately 4 feet below ground level. It is believed that the sheathing plank will last indefinitely under these damp conditions. If in years to come, however, it is necessary to replace the tops of said plank sheathing, this can be done at small expense.

The water level with the gallery in service is drawn down about 4 to 5 feet. This collecting gallery will afford an ample supply for the needs of the city for some years in the future. The city is not using the amount that the gallery will afford, which at present is approximately 300 gallons per minute.

In order to deliver the water from the gallery at a depth of 15 feet below ground level, it was necessary to lay 2500 feet of 10-inch cast iron pipe connecting with the existing 8-inch machine banded wood pipe, whereby it is possible now for the city to dispense entirely with pumping its water supply, the water being delivered by gravity into two concrete circular reservoirs, each having a capacity of approximately 80,000 gallons.

Such in brief is a description of the methods adopted to obtain the required additional water supply. The cost for the 300 feet of collecting gallery complete was $11,500.

WATER PURIFICATION FOR SMALL CITIES[1]

By H. V. Pedersen[2]

Is it practical for a city, as small as 1000 population, so unfavorably located as not to be able to secure a sufficient quantity of safe and palatable water for public use from wells, to consider the installation of a purification plant and develop a surface water supply? Anyone answering this question definitely, either negatively or affirmatively, might be accused of rather hasty decision as one answer might be just as incorrect as the other. The correct answer as applied to a particular community depends largely upon local conditions, and should not be made until all of the determining factors have been carefully studied. But I shall go as far as to say that, when a small city has become thoroughly dissatisfied with its old well supply, and determines on a change, the development of a surface supply should in all cases at least be considered.

Every city regardless of its size should choose or develop the safest, most palatable, and most practical water supply for public use that it can. Some few cities in Iowa are so favorably located that they have no problem whatever in securing an excellent public water supply. Nature provided an abundance of clear safe water within easy reach, and the city officials of the past only needed to dig a well, install a pump and pay the power bills to fulfill the duties of their offices. It was so easy that it required no thinking, and it cost so little that the general public came to take it all for granted.

Many other cities, however, have not been so favorably located. Nature was not so kind to them, and they have been compelled to spend large sums of money developing a well water supply. Although the State as a whole has been blessed with an abundance of underground water, there are sections where this water cannot be considered a satisfactory public supply, because of the mineral content and objectionable tastes. Many of the shallow water bearing sands are loaded with iron, and many of these sands lying beneath

[1] Presented before the Iowa Section meeting, November 7, 1924.

[2] Sanitary Engineer, State Board of Health, Des Moines, Iowa.

or adjacent to a city or town do not produce a bacteriologically safe water supply at the present time.

The northern half of the State is generally thought of as having an inexhaustible supply of unquestionably safe underground water. There is no question but that there is a large quantity of water, but it is amazing how rapidly this water is diminishing. Just what may be the cause of the lowering of the water table is difficult to say, but we are inclined to believe that it is due to the fact that the underground water is being used up in a wasteful manner faster than it can be replaced.

The greater part of the northern half of the State is underlaid with a limestone formation. A well drilled into this formation years ago was rarely cased below the stone. Many cracks and crevices have gradually opened, and enlarged, due to erosion and exposure, allowing unpurified surface water to pass for long distances and contaminate a vein of water that has furnished the public water supply. The majority of these deep wells produce a very hard water. Some of the waters are so hard and so full of iron, carbon dioxide, and other corrosive agents, that the life of the best well casing is not over twenty years. Thus it is that many deep wells which were once perfectly safe, now produce a water which is contaminated, and rendered unsafe from sources that are beyond human control.

Some Iowa towns have been trying for years to develop a satisfactory well water supply. In the southern part of the State some cities have not been able to locate an adequate well supply, and have therefore simply done without a public water system. Three cities within the last year located in the southern half of the State installed water purification plants as a result of long years of waiting. In a northern part of the State many towns have been getting along as best they could on a hard disagreeable-tasting water for they believed there was nothing that could be done or that there was no way to obtain a more palatable water supply. Several cities within the last year have installed softening and iron removal plants, which have proved satisfactory. The great majority of the towns, however, have continued to use a hard unpalatable, unsafe and an altogether unsatisfactory well supply because they are under the impression that it is impractical or impossible for them to consider the development of a surface supply, or do anything to improve their well supply.

For the benefit of those small cities in the State so located that they cannot secure a good underground water supply, I am going

to relate the experiences of several cities, that have taken place within the last few years.

The city of Adel, with a population of about 1500, did its best for years to put up with a shallow well water that contained a great deal of iron, was hard, and had a disagreeable taste. Finally the public refused to stand it any longer, and the council decided to make every effort to secure a more satisfactory supply. All of the available underground supplies in the near vicinity were located and tested with little success. After a careful search a good shallow water-bearing sand was located about $1\frac{3}{4}$ miles from the city, which furnished an excellent water. After the council had deliberated and carefully considered the advisability of treating the water in the original old well, and the development of the new shallow well proposition, it finally decided to construct a small rapid sand filter plant and purify the water from the Raccoon River, on whose banks the city is located.

A contract was entered into, and as a result the city now has a 120,000 gallons per day purification plant. The water is first pumped from the river to a small aërator, from which it flows by gravity into a coagulation basin 9 feet wide, 32 feet long and 12 feet deep, where the water is treated with alum and allowed to settle. From the coagulation or settling tank the water flows by gravity through a sand filter 5 feet wide and 8 feet long, to a clear well. This clear well has a capacity of about 4000 gallons. From the clear well the water is pumped into the distribution system which includes a storage or pressure tank. Liquid chlorine is injected into the water at the intake of the high duty pump to insure sterilization.

The question might be raised as to the wisdom on the part of the city in installing the above plant in preference to developing the shallow water-bearing sands located $1\frac{3}{4}$ miles distant. It cannot be denied, however, that a fine filter plant was secured at a total cost of about $11,000 complete, including a chlorinator. As it was estimated that it would cost in the neighborhood of $25,000 to develop the shallow well, it is evident that the city made a considerable saving as far as first cost was concerned. Viewed from the eyes of the public the city council secured a good filter plant capable of furnishing a comparatively soft, clear, safe water for public use at a saving of $12,000 or more and it is satisfied.

The city of Sigourney, like Adel, also had its past troubles, but its experiences were of an entirely different nature. On the advice of some local genius a council some years ago carried a water main 5

miles distant to a small river where a natural purification plant was to be developed. The attempt to develop a natural filter was a complete failure, due entirely to improper advice and design. As no other supply was available, and as the resources of the town had been completely drained, the city had to put up for years with the very unsatisfactory, dirty, raw river water that could not be used for drinking or culinary purposes.

Finally a city council determined to secure a better water supply. They brought in a number of consulting engineers to advise them. Three out of four engineers advised the council to install a modern rapid sand filtering plant, on the ground that the deep well water would contain a great deal of objectionable mineral salts which would cause a taste. No amount of advice could impress the council, or overcome the memories of the past sad experiences, and a contract for a deep drilled well was let. The deep well, drilled within the city limits, a pump house, and pumping equipment was installed for approximately $30,000. As predicted, the water from this well is very hard, and contains such an amount of mineral salts, that it cannot be considered satisfactory for drinking purposes. The public is dissatisfied with the result and prefers to use private, shallow, contaminated wells in preference to the public supply.

The city of Adel might have been able to develop a good shallow well supply, but they chose to treat or purify a surface water which in this case was the cheaper method. Sigourney might have developed an excellent surface water, but chose to develop the hard impalatable deep water at great expense, because they believed a surface water could not be purified to be fit for drinking purposes no matter what it might cost.

The chief argument which discourages the development of a surface water supply, is the operation. No one can deny that a water purification plant must be given careful, intelligent attention, or it will prove a failure. I do wish to emphasize, however, that a small city need not think that it must necessarily employ a high priced engineer to operate a water purification plant. A conscientious, industrious, intelligent man may be placed in charge, and taught in an amazingly short time all there is to know. In the small city a plant may need to be operated only half of the day. The operator might therefore be a commissioner of streets, or be given some similar office, whose duties can work in well with his duties as operator. It is evident that the larger the plant the more time is required for

operation, and naturally the various problems increase in magnitude, but the point is that a good intelligent local man, if he is the right man, can be developed into a competent operator in a surprisingly short time, if given an opportunity. No small city need continue to be without a public water supply, or use a bad well water for fear that they could not find a man to operate a purification plant in a successful manner, provided they are willing to pay a fair salary.

The question of cost of operation also enters into the problem of deciding whether the development of a surface supply is practical. Much can be said on the subject. It is no doubt true that it would cost more to operate a purification plant in some places than it would to operate a well supply. Every water works system no matter how simple it is must have some sort of caretaker in charge. The majority of the public water systems of Iowa have a caretaker who devotes from one to twenty-four hours per day. It is not necessary to increase the number of men to take care of the average small city purification plant. The same intelligent caretaker who can take care of a well system, could with a little more time take care of a properly designed purification plant. At Adel the operator spends about one-half of his time at the plant, the rest of the time he is taking care of extensions or acting as assistant street commissioner. Although the cost of operating a purification plant, therefore, is greater than that of a well system, it cannot be said that the cost is excessive or prohibitive.

It has been definitely proven in other states, as well as in our own, that the purification of a surface water supply is practical. I wish to go on record for believing that, when a city of 1000 population and upward is dissatisfied with its public water supply, it should at least consider the development of a surface supply before it spends a great deal of money in developing or adding to an already unsatisfactory supply.

PERMANENT STANDARDS FOR WATER ANALYSIS

By F. R. Georgia[1]

Many colorimetric methods are employed in the analysis of water. In certain of these methods more or less permanent standards of comparison may be prepared and used.

These standards are frequently kept in stoppered Nessler tubes or in bottles from which they must be transferred to tubes for use. In any case the standard solutions are exposed to evaporation and probable contamination every time they are used.

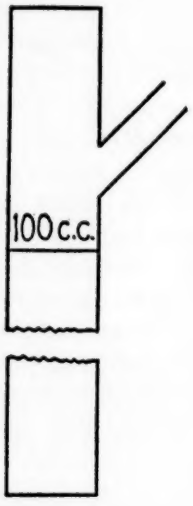

Fig. 1

In order to eliminate these objections the tube shown in figure I was designed. This tube is the same size as a 100-cc. Nessler tube, but is closed at both ends and the ends are polished. A side arm is provided for filling the tube. After filling to the graduation on the tube the side arm is closed off. A series of tubes is prepared to cover the range desired. The standard solution in such a tube is protected

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from external contamination since it is not opened for use. The only contamination that can take place is such as might result from the glass of the tube itself.

If one looks down through a tube of this sort the eye focuses on the upper end of the tube rendering it difficult to make a comparison with the usual tube that is open at the top. In order to get rid of this difficulty a colorimeter of the Woulff type was rebuilt so that it would handle these tubes and the usual 100-cc. Nessler tubes. In using a colorimeter the eye is focussed on the prism of the instrument and one is not conscious of whether the observation tubes are closed at the top or not. With this instrument comparisons with standards in the tubes above described are as easily made as with other tubes.

Since the tubes are not completely filled some of the vapor from the solution in them may condense and form drops on the tops of the tubes. These drops may be removed by inverting the tubes momentarily.

Tubes of this type are a great convenience in colorimetric determinations where the standards are reasonably permanent.

DISCUSSION

SPECIFICATIONS FOR COLD WATER METERS

The following information is the result of a conference between W. W. Brush, Deputy Chief Engineer of the Department of Water Supply, City of New York, and Chairman of the New England Water Works Association's Committee on Standard Specifications for Water Meters; C. M. Saville, Chief Engineer of the Hartford Water Works and Chairman of the American Water Works Association's Committee on the same subject; S. M. Van Loan, Deputy Chief of the Bureau of Water, Philadelphia and a member of the American Water Works Association's Committee; R. K. Blanchard, Chairman of the Meter Manufacturers Committee on Specifications; and the undersigned. The conference was called to interpret certain paragraphs of the specifications for cold water meters.

The Standard Specifications for Cold Water Meters, adopted by the Water Works Associations, does not provide for any tolerance. It is, therefore, impossible to expect the specifications to be complied with exactly in so far as they stipulate dimensions or their equivalents. Practically this has not been found to be of any consequence, since all of the meter manufacturers are working in accordance with the specifications and no difficulty has thus far resulted.

The following comments are submitted.

External bolts. The sentence "Nuts shall be designed for easy removal after having been long in service" means that provision shall be made either by the use of different metals or compositions, or possibly in the form of the threads so as to avoid nuts and bolts rusting together and preventing the easy removal of the nuts. Practically, it generally means the use of a composition nut at least or the avoidance of the use of steel nuts and steel bolts.

Registers. No particular difficulty has been experienced from the failure to stipulate minimum capacities of registers and maximum indications of initial dial in gallons as well as in cubic feet. Practically, it would be interpreted that the maximum indication of the initial dial corresponding to 1 cubic foot would be 10 gallons; to 10 cubic feet 100 gallons; and so on. Similarly for maximum register

capacities, where 100,000 cubic feet is stipulated, one million gallons would be taken for registers in gallons.

Connections for $\frac{5}{8}$-, $\frac{3}{4}$- and $\frac{1}{4}$-inch sizes. The gages referred to are the American Briggs which have been adopted by the American Society of Mechanical Engineers and the American Engineering Standards Committee. The Briggs standard gages are tapered, so that it did not appear necessary to say in the specifications that a tapered thread was to be used.

We understand that in practice the manufacturers have assumed that "within one thread of through the gage" means the minimum limit of size and that the specification was practically complied with if the gage could be screwed on to a point between three threads and one thread of through the gage.

In the case of the plug gages, we understand that the term "backed into the nuts" is a common shop phrase used by the manufacturers, intending to mean, screwed into the nuts, and that here again the manufacturers have assumed that the specifications would be practically complied with if the plug gage could be screwed into the nuts to a point between two threads of through the gage and flush.

Seal wire holes. There are not enough meters larger than 2 inch in size to warrant calling for drilling the nuts for seal wire holes for these sizes. Plants using water enough to require so large meters would almost invariably have mechanics who could arrange by-passes or some other means of stealing water, if they were so inclined, more easily than by shifting large meters. In these cases, sealing of register box so that the registration may not be tampered with appeared to be sufficient.

Measuring chambers. The word "sensitiveness" is intended to include accuracy as well. It is intended that the meter shall operate within the tolerances provided in later sections under any pressure up to 150 pounds. A meter is not considered to be "operating" unless it records the quantity of water passed within stipulated limits of accuracy.

Intermediate gear trains. It is equally important that bushings of any material should be so constructed that they cannot drop out.

Strainers. At least one meter manufacturer constructs meters of such design that the water passes through an annular space between the measuring chamber and the external case which is of such dimensions and form that it serves as a strainer, in which case, no strainer of the screen type is necessary.

Registration. It is satisfactory to have a meter tested under any working pressure up to 150 lb.

CHARLES W. SHERMAN,
Chairman, Joint Committee of American and New England Water Works Associations Upon Standard Specifications for Water Meters.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12:** 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Largest Artificial Reservoir. ANON. Eng. and Cont., **64:** 835–44, 1925. Description of the Queen Mary Reservoir which is to supply city of London, England.—*C. C. Ruchhoft.*

How Santa Barbara Water Works Went Through the Earthquake. ANON. Eng. and Cont., **64:** 824–25, 1925. Excerpts from bulletin issued by Allied Architects Association of Los Angeles containing reports and comments.—*C. C. Ruchhoft.*

A Little Known Fluid Principle and Its Practical Application. EUGENE F. DELERY. Eng. and Cont., **64:** 1043–49, 1925. Strainer system of New Orleans filters, which was designed to take advantage of velocity head, is described.—*C. C. Ruchhoft.*

Effect of Gravel Wall on Well Production. A. W. Ross. Eng. and Cont., **64:** 1084–85, 1925. Dug well lined with steel caisson 28 feet in diameter and 32 feet deep had six 6-inch wells drilled in it to top of water bearing stratum, and only furnished 1100 gallons per minute. A 24-inch gravel wall type well was put down inside dug well to depth of 78 feet thereby increasing capacity of well to 2400 gallons per minute.—*C. C. Ruchhoft.*

Chicago Water Works Notes. ANON. Pub. Works, **56:** 443–44, 1925. Excerpts from report of Chicago Department of Public Works for 1924 on cutting large mains, use of leadite, pressure control, stopping underground leakage, fire hydrant damages, and chlorine booths.—*C. C. Ruchhoft.*

Tunneling for Sewers in St. Paul. GEORGE M. SHEPARD. Pub. Works, **56:** 433–37, 1925. Methods used in driving a 12-foot and an 8-foot tunnel are described.—*C. C. Ruchhoft.*

Prevention of Deposit in Water Mains. WILLIAM RANSON. Munic. and County Eng., **69:** 324–25, 1925. Deposits of iron formed chemically and by iron bacteria are discussed. Cement lining, or coating pipes with mixture of coal tar or pitch oils and rosin is recommended to prevent chemical incrustation. Efficient filtration with removal of organic matter will prevent development of iron bacteria.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Some Results of Pipe Cleaning. B. B. HODGMAN. Jour. New Eng. Water Works Assoc., 39: 2, 171, June, 1925. Experiences over a period of twenty years in cleaning pipe mains.—*W. U. Gallaher.*

Iodine and Water Supplies. H. W. CLARK. Jour. New Eng. Water Works Assoc., 39: 3, 204, September, 1925. Concise history of iodine-goiter situation. Concentration of iodine in Massachusetts water averages 2.14 p.p.b., varying from 0 to 6.3 p.p.b. Iodine deficiency may be overcome by using iodized table and food salt, and sea foods.—*W. U. Gallaher.*

The Water Works of Quebec City. J. A. TREMBLAY. Jour. New Eng. Water Works Assoc., 39: 3, 208, September, 1925. Development of Quebec water works is described. Present source of supply is the St. Charles River. Water flowing by gravity seven miles to city is delivered at pressure of 50 to 110 pounds per square inch.—*W. U. Gallaher.*

The Filtration Works of the City of Montreal. F. E. FIELD. Jour. New Eng. Water Works Assoc., 39: 3, 213, September, 1925. Montreal has 50 m.g.d. filtration plant, water first going through rapid sand, then through slow sand filters. There are sixteen of each type; former, having combined area of 19,200 square feet are washed with air and water; latter, having combined area of 256,000 square feet are washed by means of two Blaisdell machines. The filtered water reservoir has a capacity of 6¼ m.g. (Imp.). Plant is now working 20 per cent in excess of designed capacity. Bacterial efficiencies are as follows: pre-filters (rapid sand) from raw water—66 per cent; final filters (slow sand) from pre-filters, 89 per cent; from raw water, 95 per cent. Wash water used; on pre-filters, 0.39 per cent, on final filters, 0.09 per cent; total, 0.48 per cent. Total operating cost for Montreal plant is $2.50 per million gallons (U. S.). New 30 m.g.d. pumping station and new 20 mg. (Imp.) filtered water basin have been recently built. New 100 m.g.d. (Imp.) rapid sand filter plant is soon to be constructed.—*W. U. Gallaher.*

A Fineness Modulus for Filter Sands. R. G. TYLER. Jour. New Eng. Water Works Assoc., 39: 3, 239, September, 1925. Progress report on work to perfect a method for designating size of filter sands. Following conclusions are drawn: (1) surface modulus of a filter sand gives fair approximation of transmission capacities and head losses under varying conditions of discharge; (2) it gives more accurate results with sands tested than other methods now in use based upon mechanical analyses of materials; (3) a sand is defined more specifically by its surface modulus than by its effective size and uniformity coefficient; (4) the King aspirator is indicated as a most accurate instrument for predicting flow through sands. Ibid. 39: 4, 456, December, 1925. F. HANSEN and G. F. CATLETT. Discussion of above paper.—*W. U. Gallaher.*

Some Features of Filter Design. J. W. ARMSTRONG. Jour. New Eng. Water Works Assoc., 39: 3, 254, September, 1925. Quickness of settling is increased in proportion to number of baffles in mixing basin. Placing of submerged cross baffles with parabolic shaped tops in coagulation basin causes

more uniform deposit of sludge. Concrete constructions must be impervious to water, especially in cold climates and where water is capable of dissolving calcium and aluminum compounds. Money can be saved by not building filters over filtered water reservoir and by using wood instead of concrete for elements continually submerged. The potentiometer may be used to determine the pH and to control accordingly the dosage of lime and, in some cases, of alum. Slat bottoms for filter beds are perhaps the most economical distributing systems. Filter sands should be uniform. A turbidimeter designed by Baylis which will read to within one-tenth of one part per million is illustrated and described. Turbidity in effluent at Baltimore plant is used instead of loss of head as key to washing filters.—*W. U. Gallaher.*

Lawrence, Mass., Water Supply—Investigations and Construction. M. KNOWLES, M. MANSFIELD, and P. NUGENT. Jour. New Eng. Water Works Assoc., 39: 4, 345, December, 1925. Present water supply at Lawrence, the Merrimac River, is insufficient and also very unsatisfactory due to disagreeable tastes and odors. In 1916, money spent for spring water in city equalled more than half amount of revenue from water-rate payers. Development of new supply is being continually delayed. New three-quarter acre slow sand filter to temporarily augment present supply is being constructed and new low service pump is to be installed.—*W. U. Gallaher.*

The New Little Quittacas Intake at New Bedford, Mass. F. A. BARBOUR. Jour. New Eng. Water Works Assoc., 39: 4, 370, December, 1925. Detailed account of construction of 60-inch pre-cast concrete intake conduit 1300 feet long, also of intake tower and screens. Article is profusely illustrated and full of construction details and expedients.—*W. U. Gallaher.*

The New Sebago Lake Intake and Conduit of the Portland, Maine, Water District. L. METCALF, H. U. FULLER., and C. B. MITCHELL. Jour. New Eng. Water Works Assoc., 39: 4, 394, December, 1925. Construction of 54-inch intake, 1580 feet long, terminating in gate and screen house over vertical shaft descending to tunnel in rock. Tunnel is 60 inches in internal diameter, 2100 feet in length, and discharges into 54-inch reinforced concrete conduit 1900 feet in length connected to existing supply mains. Much of tunnelling was done under air pressure. Construction costs, details, and illustrations are numerous.—*W. U. Gallaher.*

The Coolgardie Pipe Line in Australia, and Measures Taken to Prevent Corrosion. F. F. LONGLEY. Jour. New Eng. Water Works Assoc., 39: 4, 421, December, 1925. The Coolgardie pipe line put into use in 1902 is a lock-bar 30-inch steel pipe 350 miles long. Its carrying capacity was much reduced during first few years of use due to tuberculation. Corrosion also caused many perforations, the number per year increasing as time went on. Mill scale was found to have great influence on pitting, and failure of protective coating of coal-tar asphalt mixture, due partly to weather and soil, encouraged deterioration. Lime added at rate of 4 grains per Imp. gallon decreased carrying capacity of pipe so much that its use was discontinued. Deaëration of the water by

vacuum reduced oxygen content 90 per cent, but its effect on carrying capacity of pipe is indefinite, pipe delivery being constant for last few years. If pipe were new, effect of deaëration would be more pronounced. Pipe is being uncovered to avoid soil effects and policy of removing leaky sections, repairing them, and inserting them in place of others needing repair has been adopted.—*W. U. Gallaher.*

Substitution of Machinery for Hand Labor in Pipe Laying. S. H. TAYLOR. Jour. New Eng. Water Works Assoc., 39: 4, 445, December, 1925. Use of steam shovels with special appliances, gasoline driven air compressor for handling ledges and boulders, gasoline driven pumps for taking water from wet trenches, and two or three trucks with dump bodies, made possible reduction of crew to 15 or 20 men when laying pipe in long trenches. From 120 to 180 feet laid per day at cost of 26.34 dollars per foot. Method is not practical for short lines scattered over system on account of cost of moving apparatus long distances. Three men averaged one lead joint in one hour and forty minutes at total cost of 18.06 dollars while same three men averaged six to eight joints per hour with leadite at total cost of 4.42 dollars each joint.—*W. U. Gallaher.*

An Emergency Water Supply for Leominster, Mass. W. G. CLASSON and C. W. SHERMAN. Jour. New Eng. Water Works Assoc., 39: 4, 450, December, 1925. Reservoirs constituting city's supply became so low in December, 1924, that permission was received from State Commissioner of Health to take water from Smith Pond on Monoosnoc Brook. Pump was installed, water was treated with 0.74 p.p.m. chlorine and fed to city mains. Cost amounted to 196.91 dollars per million gallons. Idea was later conceived of filling Fall Brook high pressure system reservoir which was low, with water from distributing low pressure system reservoir, which was full and overflowing, by diverting through mains. Cost amounted to 40.49 dollars per million gallons.—*W. U. Gallaher.*

Flow of Fluids in Pipe Bends. J. EUSTICE. Water and Water Eng., 26: 270, July 21; 301, August 20; 362, September 20; 392, October 20; 432, November 20, 1924. As result of application of colored filaments to flow of water in glass tubes author states that increased resistance to flow in curved pipes is due to difference in pressure between outer and inner radius of bend caused by centrifugal force, hydraulic gradient from outer to inner walls of the curve being established. Water follows path of least resistance so as to form vortices. If straight length follows at outlet end of bend, vortices formed in bend persist for considerable distance along the straight. Hence, gaugings taken along to a bend are not reliable, and investigators who have not recognized this have sometimes obtained results for resistance of bends which are misleading. Results of the author's experiments on resistance in wrought iron elbows, screwed over pipes, and wrought iron bends, from 0.2 to 2 inches in diameter are summarized and empirical formulae given. Results are also given of experimental researches on "skin" pressure exerted on pipe by water flowing through a bend. Experiments show that skin pressure at outer radius increases gradually to maximum at or near centre of right-angled bend, while a

somewhat similar gradual decrease occurs at inner radius. Experiments were made to determine the resistance in coiled pipes and through bends in series; and to determine the differences in pressure at different points of an elbow. References are given to papers on this subject by other investigators. Illus.—*Geo. C. Bunker.*

A New Deep Well Pumping Installation, Tunbridge Wells Corporation Waterworks. W. H. MAXWELL. Water and Water Eng., **26**: 427, November 20, 1924. Detailed description of lining of two borewells of 38¾ inches in diameter at top and 336 feet deep and of pumping plant capable of delivering 74,830 gallons per hour. Illus.—*Geo. C. Bunker.*

The Employment of Storage Reservoirs in Irrigation, with Special Reference to the Krian, Perak, Irrigation Undertaking. F. W. MAGER. Water and Water Eng., **26**: 435, November 20, 1924. Description of works for irrigation, for rice culture, of 42,000 acres of Krian district in state of Perak, Federated Malay States, largest irrigation work so far constructed in British Malaya. Abstract of paper communicated to Institution of Civil Engineers.—*Geo. C. Bunker.*

Water Power in the Netherlands East Indies. P. C. COOTE. Water and Water Eng., **26**: 437, November 20, 1924. Data are given concerning sources of water power and the more important power stations in Java, Sumatra, Dutch Borneo, and Celebes.—*Geo. C. Bunker.*

Vegetable Decomposition in Ditch Water Simulating Sewage Contamination. L. COBBETT. Water and Water Eng., **26**: 445, November 20, 1924. Abstract from Jour. of Hygiene **22**: No. 4, July 1924. Late in autumn of 1922, following exceptionally dry period, water in some of ditches in low-lying land on west side of River Cam, where it flows past some of colleges from Queen's to St. John's, became foul, so that instead of looking dark and clear, as usual, it appeared milky, and gave off an offensive odor so like that of sewage that many people believed that it had become containated by leakage from sewer near by. This led to an investigation which proved that no pollution with sewage was taking place. On the other hand certain bacilli with single flagella were isolated from the water and found capable of giving off from their artificial cultures odor comparable to that of ditches. To these bacilli, acting on dead leaves in water, and probably in conjunction with other anaërobic bacteria generating hydrogen sulphide, sewage-like odor was attributed.—*Geo. C. Bunker.*

Ismailia Valves. Water and Water Eng., **26**: 447, November 20, 1926. So named because first installed at Ismailia Pumping Station, Cairo. It was designed to meet the conditions of pumping crude sewage and surface water, heavily charged with grit, sand, refuse, and solid matter, against a head of 300 feet. In practice, valve proved itself an unqualified success. It is a clear way valve without the disadvantage of a hinge, and is free to seat evenly like a disc pump valve; it works equally well whether placed horizontally or vertically and, owing to its simple construction, may be faced with any material to

suit nature of liquid pumped. Valve consists of two castings; accessories such as nuts, pins, washers, and screw threads are eliminated. Illus.—*Geo. C. Bunker.*

Standard Tests for Hydraulic Power Plants. Water and Water Eng., **26**: 151, April 22, 1924. Report of joint committee of Institutions of Civil and Mechanical Engineers. In appendix (page 144) are given systems generally used for determining volume of flow when direct volumetric measurement by means of measuring basin is not feasible: viz., venturi meter; pitot tube; weirs; current meters; salt solution method; floats; and travelling screen.—*Geo. C. Bunker.*

Bristol Waterworks: Cheddar Supply. A. M. PATERSON. Water and Water Eng., **26**: 268, July 21, 1924. Cheddar supply is a standby and comprises following works: intake on stream at Cheddar; 33-inch cast iron gravity main from intake to pump station; pumping main, 9½ miles long, of which 7½ miles is 33-inch and remainder, 24-inch cast iron pipe; 500,000-gallon service reservoir near summit of pipe line; drainage and sewerage works at Cheddar. Steam excavator was used for cutting pipe trench, excepting where rock was met; under best conditions it cut 440 yards of 33-inch pipe trench in 49-hour week; its normal rate of travel was 6 to 7 yards per hour. Average total cost of excavation was approximately 3s. 3d. per cubic yard, with labor at 1s. 7d. per hour, and plant bought when prices were a maximum. Cost of hand excavation would have been 5s. Over 75 per cent of joints were caulked by pneumatic caulkers operated by petrol-driven air compressor. Lead was used, 2¾ inches deep in 33-inch pipe joints. Jointers worked in pairs and 2 men would set up joint in 15 minutes. Backfiller was petrol-driven machine which dragged the material into trench by scoop working on drag line. Cost of refilling 33-inch pipe trench by its means was 4s. to 4s. 6d. per linear yard, little, if any, saving over hand labor. Pumping plant consists of 3 independent sets of high speed centrifugal pumps driven through intermediary of toothed helical gearing by solid injection crude oil engines. Each unit is rated at 1400 g.p.m. against total head of 306 feet. Engines are of Ruston-Hornsby two-cylinder horizontal type, built for working load of 234 b.h.p. Pumps are Mather and Platt 8-inch split casing 5-stage centrifugals, designed to run at speed of 1000 r.p.m. Conditions under which plant will operate initially are materially different from those which will ultimately obtain. Present working head with 3 pumps running is about 261 feet. By throttling discharge valves head was increased to 303 feet and pump discharge of 1680 g.p.m. obtained. Oil consumption per brake h.p. hour under these conditions was 0.44 pound, or 0.62 pound per horsepower delivered to main with brake h.p. of 220. Tests were also made at reduced speed, delivery valves being wide open; with the 3 units running together oil consumption was 0.42 pound per brake h.p. hour, or 0.59 per pump h.p. hour, at an average of 170 brake h.p. per unit and pump efficiency of 73 per cent.—*Geo. C. Bunker.*

South Staffordshire Waterworks. Water and Water Eng., **26**: 271, July 21, 1924. From a brochure prepared by FRED J. DIXON, Chief Engineer. South

Staffordshire Waterworks Co. was established in 1853. Statutory district of supply extends into counties of Worcester, Warwick, Stafford and Derby, having collective area of some 297 square miles. Geologically, area supplied is composed of aqueous and stratified rocks formed during four different geological periods, viz., silurian, carboniferous, permian and triassic. Mean annual rainfall for 31 years period for company's area of supply is 24.33 inches. Bulk of water supplied is obtained from subterranean sources by means of deep wells, borings, and headings, and therefore has to be pumped to surface. There are 15 principal pumping stations, 7 secondary or repumping stations, and 18 impounding and service reservoirs. Owing to the undulating configuration of area of supply, distribution system is somewhat complicated. Sources of supply being nearly all on fringe of district, large and long pumping mains have been necessary. All the water has to be pumped; in 1923 total quantity pumped was 6,618,991,639 gallons; in addition 2,029,805,813 gallons were repumped to higher districts, some water having to be pumped 3 times. Average consumption per head per day in 1923 was; domestic 19.5 gallons; trade and other purposes, 4.2 gallons total 23.7 gallons. Total estimated population supplied with company's water on December 31, 1923, was 763,305, number of houses supplied being 152,661, and number of meters in use 4,341. Only water at present filtered is that from Brindley Bank boreholes. Mather and Platt's pressure filters, without coagulants, are used; solely for purpose of removing what are termed "iron bacteria." Brief descriptions of Wood Green, Slade Heath, Somerford, Pipe Hill, and Maple Brook pumping stations are given. Details are given concerning repairing, lining, and covering Shire Oak reservoir, capacity 4,250,000 gallons, constructed as an open reservoir during 1896–7. Floor consisted of mass concrete on gravel foundations; walls, also of mass concrete, having vertical water faces and being stepped on back. Floor and walls were faced with blue bricks. In January 1900, cracks which rendered reservoir useless developed in bottom, movement being due to subsidence consequent upon working of colliery at Walsall Wood.—*Geo. C. Bunker.*

Collapse of Perth, Western Australia, Filter Beds. Water and Water Eng., **25**: 291, July 21, 1924. Abstract from Commonwealth Engineer, April, 1924, pp. 373. Report, after Government inquiry, on collapse of north wall and conduit system of filter beds in connection with metropolitan water supply. Findings were (1) that failure was due to faulty design and construction, (2) that pillars supporting concrete conduit collapsing, the whole falling mass pulled down wall, (3) that if conduit system had not been attached to wall, and if wall had been reinforced, as in the design, failure would not have taken place. Chief engineer, owing to press of work, had not had time to inspect construction, which was regarded as of minor importance, and chief draughtsman had not in this case checked figures of his subordinates. Recommendations were that chief engineer should in future inspect all plans and drawings and give advice thereon.—*Geo. C. Bunker.*

Pumping from Wells and Boreholes. (The Application of the Turbine Pump.) F. Johnstone-Taylor. Water and Water Eng., **26**: 304, August 20, 1924.

At head of well is substantial frame. This serves two purposes: first, to support either a vertical electric motor for direct drive of pump, or if this is inadmissible, a gearbox for transmitting power from some other form of prime mover; second, to support from its base delivery pipe in well, which in turn supports pump, from which are hung suction pipe, foot-valve, and strainer. Inside delivery pipe or trunk tube is the vertical shaft. At rest, this shaft is entirely in tension; when running, tension is taken up by a thrust bearing, but the load thereon is somewhat balanced by hydraulic balance of pump, allowing shaft practically to float. Its steady running is ensured by lignum bushes, set in housings gripped between flanges of pipes. This arrangement permits accurate alignment of the lignum bearings which, running under water, cannot seize and require no lubrication. Mechanical construction thus permits of shaft of considerable length running at high speed without vibration, whole system from frame downwards being free to take up position of self-alignment. Apart from steam, not an economical proposition for small plants, and electric power, not always available, choice lies between gas and oil, necessitating gearing in either case. Diesel or semi-Diesel engine running on crude oil is likely to find greatest favor. Brief descriptions are given of installations at Ipswich, Doncaster waterworks, and Somerford pumping plant of South Staffordshire Waterworks Company.—*Geo. C. Bunker.*

Purification of Coke Quenching Water. Water and Water Eng., **26**: 381, September 20, 1924. Report on investigations into amount of poisonous matter discharged from coking ovens into River Marne states that analyses showed traces of phenol and notable quantities of hydrosulphuric and hydrocyanic acids, varying in accordance with place of origin of coal used, English coal being more sulphurous than that of the Sarre and the Ruhr. Existing purifying apparatus consisted of successive barriers of perforated planks placed across outfall ditch. Planks enclosed beds of coke and iron residue; water passing through these rough filters carried on surface traces of tar and naphthalene which were skimmed off now and then by hand. The filters retained about $\frac{1}{4}$ of acids contained in water. For remainder, Dr. DURAND advised purification by means of strong solution of chloride of lime containing carbonate of soda. He gives following method for determining amount of concentrated Javel water required to purify 1 liter of water; place in saturation tube 200 cc. of water to settle, add 3 or 4 drops of sulphuric solution of indigo-carmine, and then drop by drop, by means of a Mohr burette, Javel water until blue color disappears; number of cubic centimeters used multiplied by 5 gives quantity of Javel water required to purify 1 liter. Purification of waste water is carried out in basins of known capacity communicating with works channel, dosage necessary being put into basin before water from channel is let in.—*Geo. C. Bunker.*

Use of Plastic Refractories in Boiler Furnaces. H. E. WEIGHTMAN. Power, **63**: 3, 90, January 19, 1926. Some practical hints given. Discussion includes construction of walls, necessity of rigid foundations, construction of suspended parts, proper initial firing of plastic walls, control of the water smoking period, rules for cooling, characteristics of plastic refractories, modulus of rupture, testing the material, and cost consideration.—*Aug. G. Nolte.*

Effects of Changing the Load on a Synchronous Motor. J. M. CUNNINGHAM. Power, 63: 3, 99, January 19, 1926.—*Aug. G. Nolte.*

Handling Oil-Fired Water-Tube Boilers. G. H. BRIGGS. Power, 63: 4, 130, January 26, 1926. Proper regulation of air in operating oil-burning boilers is discussed.—*Aug. G. Nolte.*

Tendencies in Electric-Motor Control Installations. J. E. HOUSLEY. Power, 63: 4, 134, January 26, 1926. Attention is called to practices that should be avoided in controller installations and examples are given of methods for mounting motor-control apparatus that make for flexibility and safety in operation and maintenance. Illustrated.—*Aug. G. Nolte.*

Economical Coal Buying. H. B. STANTON. Power, 63: 4, 140, January 26, 1926. Author points out shortcomings of purchasing on heat unit basis and offers practical suggestions for selecting coal on performance basis.—*Aug. G. Nolte.*

Boiler-Water Conditioning with Special Reference to High Operating Pressure and Corrosion. R. E. HALL. Power, 63: 5, 194, February 2, 1926. Abstract of paper presented at Midwest Power Conference, Chicago, Ill., January 27, 1926. Summarizes the conclusion of four years research undertaken to establish essential conditions for prevention of adherent scale and corrosion. Definite relations have been established between boiler pressure, sulphate concentration, and carbonate concentration needed to prevent scale formation. These concentrations are measured by simple apparatus suitable for boiler room use. Other matters of interest touched upon are use of sodium phosphate in high pressure boilers, prevention of corrosion, and avoidance of excesses of CO_2 and other non-condensable gases.—*Aug. G. Nolte.*

Checking the Accuracy of Watt-Hour Meter Connections. W. F. WALSH. Power, 63: 6, 206, February 9, 1926. Some likely meter connection errors and methods of detecting these are pointed out. Illustrated by diagrams.—*Aug. G. Nolte.*

Draft of Chimney. J. G. MINGLE. Power, 63: 7, 247, February 16, 1926. Discusses fundamental draft equation of chimney design.—*Aug. G. Nolte.*

Stokers Pay Big Dividends in Heating Plant. Power, 63: 7, 253, February 16, 1926. In a relatively small plant containing three hand-fired return-tubular boilers which operate during heating season of seven months, installation of stokers saves more than $10,0000 over hand firing and use of oil for a short period. Saving effected during heating season of stoker operation over previous hand fired conditions amounted to 73 per cent of total investment in stokers and auxiliary equipment.—*Aug. G. Nolte.*

Eliminating Boiler Scale by the Agfil Process. D. A. GARDNER. Power, 63: 7, 261, February 16, 1926. In the past, power plant experts have warned

against presence of electric currents in boilers attributing pitting and corrosion thereto. Now, however, minute electric current passed over inside surface of boiler has been found to prevent adhesion of scale to metal and to remove any scale that may have been present before the application of current. Process was invented in Europe and has been in use there for over three years. Many successful installations are now in operation in power plants and tests in this country have shown method to be equally applicable to boiler conditions here. Apparatus consists of three pieces,—a thermopile, a vibrator and an ammeter. The thermopile is fastened to the steam main or breaching; one of the electrical terminals is connected to the upper boiler drum, the other, through a vibrator and an ammeter, to the blow-off pipe. Process is very much of a mystery and all attempts to explain it have been unsuccessful. Illustrated.—*Aug. G. Nolte.*

Furnace Designs for Coal and Wood Refuse. C. M. GARLAND. Power, 61: 11, 406, March 17, 1925. Certain definite furnace designs for burning of moist or dry low grade fuels are illustrated and discussed.—*Aug. G. Nolte.*

Operation of Diesel Engines. R. HILDEBRAND. Power, 61: 11, 414, March, 17, 1925. Successful operation depends to great extent upon combustion. Quality of fuel has a vital influence. Good combustion means quick burning of fuel at beginning of power stroke while poor combustion means slow burning extending over nearly the whole power stroke. Diesel engine can burn fuel oil varying greatly in character, but desirable grade should be used, even at greater cost. Fuel oil used in this country at present is generally "topped" crude oil, i.e., a crude from which higher oils, such as benzine, kerosine, gasoline, have been extracted by distilling. Unblended topped oil is called straight-run fuel oil. Compounded fuel oil is generally made up of heavy residues from refineries and bottom sediments from storage tanks blended with lighter oils in order to obtain a fuel with a desired specific gravity. Compounded oils are frequently unsuited for use as Diesel fuels on account of high residue content when heated. Analyses made of three fuel oils show considerable variation in residue. It appears that residue content and flash and burning points are not dependent upon specific gravity, or degrees Baumé. Tests show that a certain degree Baumé does not definitely indicate whether a fuel oil is suitable for Diesel Engine. While lighter oils do not contain as many heat units per gallon as do heavier, latter must be heated to prevent sluggish flow through pipes and atomizers. As a guide for buying fuel oil, author recommends following specifications;—Grade, straight run topped crude; Gravity, 20 to 30 degrees Baumé at 60 degrees F.; Heating value, 19,000 B.t.u., or higher; Flash Point, between 125 and 250 degrees F.; Burning Point, between 160 and 300 degrees F.; Residue, not over 10 per cent after sample has been heated in closed oven 120 hours at 575 degrees F.; Sulphur, not over 1.5 per cent; Water, not over 0.25 to 0.33 per cent; Ash, not over 0.10 per cent. Methods of heating fuel oil and injecting it into pump are discussed. Sulphur and other impurities chemically affect the engine. Water, dirt, and grit must be removed before oil enters engine. Filtering will eliminate many disturbances. Storage tanks should be cleaned occasionally but precautionary

measures must be taken to avoid explosions or asphyxiation. Tanks should be ventilated and no naked flames allowed to come near openings.—*Aug. G. Nolte.*

Will Sulphuric Acid Hurt an Oil Engine. A. B. NEWELL. Power, **61**: 12, 454, March 24, 1925. For a number of years, burning of sulphurous fuel in oil engines has been known to do certain amount of damage, which often became manifest in form of pitted cylinders and valves. Sulphur in oil was blamed for this. Damage may be avoided at practically no expense while burning fuel of high sulphur content. Sulphur present in oil injected into cylinder burns without damaging engine and is converted into a gas which is harmless when hot and dry. Damage to engines has occurred after they were shut down and allowed to cool, thus causing sweating on interior surfaces. These small particles of water rapidly absorbed any sulphur present in gases left within cylinder and become dilute sulphuric acid which is very active on cast iron or steel. Since it is only necessary to have engine cleared of all sulphur fumes before it is shut down and allowed to cool, it is best, before shutting down, to switch onto some refined product such as kerosene which will contain no sulphur. Engine will be thoroughly purged of all foul gases in this way.—*Aug. G. Nolte.*

Feed Water Regulation. C. L. HUBBARD. Power, **61**: 12, 456, March 24, 1925. Radical changes in boiler design and operation require close feed water control. Water supply must closely follow steam demand through all load fluctuations. Character of load determines method of regulation to be used. Typical modern regulators are illustrated and described.—*Aug. G. Nolte.*

Modeling as an Aid in Power-Plant Piping Design. C. T. VAN DUSEN. Power, **63**: 8, 282, February 23, 1926. Representing design by models is an aid in studying relation of various systems to one another and to other elements of plant. Such matters as ready access to valves, proper clearances for maintenance work, and neat and orderly appearance of piping as a whole are taken care of less satisfactorily by ordinary draughting room methods than by models. A special wax composition is used for modeling pipe. Copper wire used as core. Important decisions reached by discussing model rather than drawing.—*Aug. G. Nolte.*

How to Figure the Capacity of Chimneys. J. G. MINGLE. Power, **63**: 8, 288, February 23, 1926. Discusses factors determining area, or diameter, of chimney.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VAN WINKLE. Power. Subjects as follow: **63**: 1, 38, January 5, 1926. Grooves in Engine Bearings; Steam-Pipe Coils for Heating Fuel Oil; Charging Refrigerating System with Ammonia; Effect of Altering Valve Setting. **63**: 3, 112, January 19, 1926. Finding Boiler Heating Surface; Air Compression at High Altitudes; Pumps Short Strokes; Groaning Steam Valves. **63**: 5, 192, February 2, 1926. Number of Phases in

a Wound Rotor for a Polyphase Induction Motor; Controlling Speed of Hydraulic Elevators; Grounding of Windings on the Rotor of Induction Motors; Dielectric Strength and Insulation Resistance. **61**: 11, 429, March 17, 1925. Hot-Water Supply to Outlet below Tank; Use for Oil Separator on Exhaust-Steam Heating System; Pounding of Simplex-Pump; Feed-Pipe Bushing; Increasing Back Pressure in Ammonia Refrigerating Plant; Unbalanced Area of Water Leg; Position of Crank at Half-Stroke of Piston. **61**: 12, 468, March 24, 1925. Thickness of Tube Sheets for H.R.T. Boilers; Centrifugal Force as Square of Velocity; Stiffness of Springs on Pump Valves; Discharge of Boiler Test Pump; Testing Leakage of Pump Valves; Source and Prevention of Clinker; Throttle Valves for Two-Cylinder Corliss Engine; Safe Pressure for Dished Heads; Relative Economy of Simple and Compound Corliss Engines. **63**: 8, 306, February 23, 1926. Starting a Centrifugal Pump; Figure Inside Area of Fire Tubes; Operating A. C. Motors in Parallel; Water Circulation on Hydraulic Elevators.—*Aug. G. Nolte.*

Present Status of Water Works Practice in Sweden. ALFRED JERDEN. Surveyor, **66**: 1702, 181, August 29, 1924. The population of Sweden (January, 1923) is 5,987,520; 1,813,177 living in the 111 cities and approximately 250,000 in towns of more than 1000 inhabitants. Eighty-five per cent of the cities, comprising 98 per cent of the total city population, have municipal water works, 95 per cent of the inhabitants of the various cities being supplied from this source. Ground water occurs relatively sparingly but there is an abundance of lakes and rivers. Per capita consumption is 17.6 Imp. gallons in metered cities and 26.4 in cities not metered.—*A. W. Blohm.* (*Courtesy U. S. Public Health Eng. Abst.*)

Rivers Pollution. C. JEPSON. Proc. Asso. of Managers of Sewage Disposal Works (England), 1923. Review of legal control over stream pollution exercised by government in England, and standards upon which such control is or should be based. First Rivers Pollution Act was passed in 1876, granting local authorities the power of taking action against persons polluting streams, but was a failure because the cities themselves were the chief offenders. Legal action for discharge of improperly treated trade wastes is usually slow and frequently hampered by saving clauses and restrictions that are taken advantage of by offenders. General rules should prohibit in trade wastes: (*a*) excessive suspended matter; (*b*) highly putrescible matter; (*c*) readily oxidizable matter (sulphides, etc.); (*d*) material acidity or alkalinity; and (*e*) sterilizing agents such as free chlorine. Suggested future requirements: (1) formation of additional rivers boards to be responsible for an entire watershed; (2) a central authority to assist rivers boards; (3) local authorities should provide sewers large enough to carry trade wastes, with power to assess special charges, if necessary; (4) manufacturers should have power to discharge waste liquors, after preliminary treatment, into municipal sewers without extra charge; (5) provision should be made to enforce and maintain satisfactory preliminary treatment of industrial wastes and prohibit discharge of wastes that interfere with sewage treatment processes; (6) creation of central research laboratory. —*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Bathing Places in New Jersey. Part II. I. R. RIKER and C. W. SPARMAKER. New Jersey Public Health News, 9: 12, 364, November, 1924. General discussion of swimming pool design and requirements. Features of recirculation and filtration systems, scum troughs and side walks, methods of disinfection, ventilation, light and heat, and accessories are discussed.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Ozonification of the Water of the River Neva. S. RASHKOVICH. Transactions of International Conference on Sanitary Engineering, London, 359, 1924. Detailed results are presented of experimental stations of the Technical Sanitary Institute of Petrograd. Most important factors in mixing of water and ozone are duration of contact, thorough mixing, volume of air used and concentration of ozone. To secure sterilization contact of ozone with the water should not be less than 10 to 15 minutes.—*A. W. Blohm.*

Supply of Drinking Water in the Dutch East Indies. JAN SMIT. Transactions International Conference on Sanitary Engineering, London, 356, 1924. Difficulties of supplying pure drinking water in the tropics are outlined. Gradual installation of central supplies has resulted in nearly 40 cities being served, at a cost of 20 million guilders.—*A. W. Blohm.*

London Water Supply Statistics, 1923–4. Surveyor, 66: 1712, 390, November 7, 1924. Daily average supply furnished was 248.87 m.g. in the direct area of supply and 2.06 million in bulk, a total of 250.93, the daily per capita supply being 36.16 gallons, an increase of 0.86 gallon over previous year.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Treatment of Moorland Surface Waters. LEWIS MITCHELL. Surveyor, 66: 1714, 423, November 21, 1924. Water supply of Bradford, Eng., is of excellent quality for domestic and trade purposes, but contains color derived from peaty gathering grounds. Scheme under consideration for removing color, consists of coagulation and sedimentation basins, rapid gravity or roughing pre-filters, and final treatment on existing slow sand filters at increased rate.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Bathing Places in New Jersey. Part III. Operation of Artificial Swimming Pools and Baths. I. R. RIKER and C. W. SPARMAKER. New Jersey Public Health News, 10: 3, 88, March, 1925. Article contains list of 34 outdoor and 82 indoor swimming pools with source of water supply, frequency of refilling and methods of purification and disinfection of water. Authors state "only six indoor pools and five outdoor pools contained water which would meet the tentative standard of the A. P. H. A. (Bathing Place Committee). The results which are greatly in excess of this standard are due in our opinion to a polluted water supply, faulty construction, poor operation, or inadequate sanitary supervision of bathers. We are satisfied that the tentative standard can be met in a properly designed and operated pool."—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

National Water Policy. Bradford Water Committee. LEWIS MITCHELL. Surveyor, 66: 1714, 422, November 21, 1924. Great need of conserving and utilizing to best advantage the comparatively few remaining unappropriated water supply areas in England is emphasized. It is suggested that every water authority should have a detailed program for 20 years in advance of requirements and general program of at least 50 years.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Aberdeen Water Supply. GEO. MITCHELL. Surveyor, 67: 1729, 280, March 6, 1925. Original plant, completed in 1866, consisted of a storage reservoir and 0.5 acre of slow sand filters, the latter subsequently increased to 2.5 acres. Plant enlarged in 1920 by 3 slow sand filters covering 1.4 acres, new intake, screening chamber, aqueduct and storage reservoir.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

The Effect on Canned Foods of Industrial Wastes in the Water Supply. E. F. KOHMAN. National Canners' Association, Washington, D. C., Circ. 4-L: 11 pp., 1923. From Chem. Abst., 17: 3062, September 20, 1923. Subjects discussed include: (1) Requirements of drinking water. (2) Requirements of canning water. (3) Contamination of water with taste-producing organisms, which condemns water for canning. (4) Contamination of water by industrial wastes. Case of by-product coke plant cited in detail, and several similar cases mentioned. (5) Production of foreign taste by chlorination. (6) Proportions of chlorine and phenol which cause taste. Results of numerous experiments given. Water containing by-product coke plant waste in any dilution is not suitable supply for canners. Chlorinated water is always source of danger in canning. Chlorine has been found to produce pronounced taste under conditions other than when polluted by coke plant waste.—*R. E. Thompson.*

The Effect of Hard Water in Canning Vegetables. W. D. BIGELOW and A. E. STEVENSON. National Canners' Association, Washington, D. C., Bull. No. 20-L: 39 pp., 1923. From Chem. Abst., 17: 3063, September 20, 1923. Effect of hard water on canning of vegetables discussed. Zeolite method is best suited for softening water for canning foods.—*R. E. Thompson.*

The Determination of Carbon Dioxide and Oxygen in Steam from Various Softening Plants. SCHIEDT and STOCKMANN. Arch. Wärmewirtschaft, 4: 7–10, 24–6, 1923. From Chem. Abst., 17: 3066, September 20, 1923. Data includes analyses of feed-water and of steam from various points in four plants. Typical values for carbon dioxide and oxygen respectively, in grams per ton of steam, are: lime-soda process, 12, 5; same, with blow-off water returned to feed, 37, 4; permutite softener, followed by degasifier, 62, 1; no softening, 68, 4. Much of carbon dioxide is derived from hydrolysis of sodium carbonate. In sampling, condensate must be collected under oil, as oxygen is rapidly absorbed from air.—*R. E. Thompson.*

Colorimetric Determination of Nitrates in Water. B. LAMPE. Wochschr. Brau, 39: 303–4, 1922. From Chem. Abst., 17: 3066, September 20, 1923.

Following simple modification of Grandval and Lajoux's method for estimating nitrates in water is not affected by presence of nitrite or organic matter in small amounts usually found in natural water. Weigh Erlenmeyer flask containing 30 cc. of sample and boil with sufficient silver sulfate solution to precipitate chlorides. Cool, make up to original weight, mix thoroughly and filter through dry filter paper until clear. Evaporate 25 cc. of filtrate to dryness in porcelain dish on water bath and mix with residue, by means of flattened glass rod, 15–20 drops of reagent prepared by mixing 0.75 gram of pure phenol with 9.25 grams of pure concentrated sulfuric acid. Transfer contents of dish to 200 cc. flask, mix with 10 cc. 10 per cent ammonia solution, and make up to volume. In presence of nitrate solution is colored yellow by formation of ammonium picrate. Prepare solution containing 3.844 grams potassium nitrate per liter, dilute 10 cc. to 200 cc., evaporate 25 cc. of diluted liquid to dryness and treat as above, making up to 500 cc. after addition of ammonia. Series of flasks similar to those used for comparing colors of worts may be employed for comparing colorations. Use of 20-mm. cell containing solution of 25 grams of copper sulfate in 100 cc. increases accuracy of comparison.—*R. E. Thompson.*

Bacteriological Study of the Water of Lake Mendota. F. C. Wilson. Absts. Bact., **5**: 11–2, 1921. From Chem. Abst., **17**: 3066, September 20, 1923. Water is stratified during summer, lower water being deficient in oxygen. Bacterial count per cc. ranges from aproximately 100 in winter to 3550 in early summer. Type of bacterial flora varies with season.—*R. E. Thompson.*

The Removal of Phenols From Waste Waters of Mining. W. Gluud and R. Schönfelder. Ber. ges. Kohlenforsch, **1**: 161–8; Chem. Zentr., 1922, IV: 697. From Chem. Abst., **17**: 3067, September 20, 1923. Recommended that waste waters from mines be extracted with solvent naphtha. Experiments were carried out with tap water containing 1 per cent phenol.—*R. E. Thompson.*

Fifty-Ninth Annual Report of the Alkali Inspector, 1922. T. L. Bailey. Gas World, **79**: No. 2033 (Coking Sec.), 14–7, 1923; Gas J., **163**: 255–8. From Chem. Abst., **17**: 3074, September 20, 1923. Work begun last year (C. A. 17, 1109) on decolorizing and dephenolating waste liquors from ammonia stills by means of flue gases has been continued and further improvement made, although purification effected does not yet equal expectations. In final effluent discharged, analysis indicates volatilization of 71 per cent of phenols with reduction of 42 per cent of oxygen absorbed. Further treatment by bacterial action on specially prepared filter beds demonstrated that these liquors could be made practically innocuous in respect to phenols, thiocyanate, and other oxidizable constituents.—*R. E. Thompson.*

Corrosion of Iron in Concrete. B. Zschokke. Concrete Constr. Eng., **18**: 393–4, 1923. From Chem. Abst., **17**: 3083, September 20, 1923. Compact concrete in sufficient thickness will protect iron against corrosion for considerable time provided shrinkage cracks do not reach iron. Coating of red lead

will prevent iron from rusting for 5 years. Problem of preventing shrinkage cracks, which appear in rich oftener than in lean concrete, has not yet been solved. Inhibitive action of chromates is being studied but conclusive results have not been obtained. Following precautions for preventing corrosion of iron in concrete recommended: (1) Concrete should not be too meager, but should contain proportion of cement which will produce greatest impermeability to air. (2) There must be no substance in concrete, such as locomotive cinders, often containing sulfur, which exert chemical action on iron. (3) Layer of concrete should be of sufficient thickness to properly cover iron, and should not crack under pressure or through shrinkage.—*R. E. Thompson.*

The Protection of Concrete and Other Building Materials Against Water and Noxious Fumes. M. Toch. Ind. Eng. Chem., **15**: 665–6, 1923. From Chem. Abst., **17**: 3083, September 20, 1923. Discussion of protection of concrete, steel and wood in buildings.—*R. E. Thompson.*

Studies on the Treatment and Disposal of Dairy Waste. C. L. Walker, et al. Cornell Agr. Expt. Sta. Bull., **245**: 120 pp. 1923. From Chem. Abst., **18**: 1019, April 10, 1924. Milk waste can be successfully treated by chemical precipitation with ferrous sulfate and lime. It is unsafe to pass whey into open water currents, even after 75–95 per cent of nitrogen has been removed by precipitation with lime and filtration. Considerable data given.—*R. E. Thompson.*

Velocity of Flow by the Salt Method. Eric Crewdson. Engineer, December 14, 1923; Chem. Met. Eng., **30**: 59–60, 1923. From Chem. Abst., **18**: 1022, April 10, 1924. Accurate index of velocity of flow obtained by measurement of time between maximum voltages recorded on voltmeters connected to source of direct current (110 volts) and to electrodes, consisting of modified spark plugs, situated 100 yards apart in pipeline carrying water to which had been added 1 gallon of saturated salt solution.—*R. E. Thompson.*

The Salt Velocity Method of Water Measurement. Chas. M. Allen and E. A. Taylor. Mech. Eng., **46**: 13–6, 51, 1924. From Chem. Abst., **18**: 1024, April 10, 1924. Method of measurement similar to that described in previous abstract outlined. Passage of salt solution between two points is accurately timed and volume of pipeline between same points accurately determined. Discharge in cubic feet per second equals volume in cubic feet divided by time in seconds. Advantages claimed include: simplicity, accuracy, applicability to any form or size of flume, pipe, or penstock, economy, non-interruption of operation, flexibility, ease of obtaining records, minimum time required, and quick calculation of results.—*R. E. Thompson.*

First (Experimental) Report to the Atmospheric Corrosion Research Committee (of the British Non-Ferrous Metals Research Association). W. H. J. Vernon. Trans. Faraday Soc., 1923 (advance proof), 62 pp. From Chem. Abst., **18**: 964, April 10, 1924. Present report deals mainly with tarnishing, as distinct from corrosion in ordinary sense. Research work included both

field and laboratory experiments. Significance of shape of curve obtained by plotting weight increment against time is discussed in relation to function of corrosion product or scale, and principle involved appears to be of much importance. Three types of curve have been distinguished, as follows: (1) Parabola whose axis coincides with time axis of coördinates. Weight increment is thus proportional to square root of time, i.e., rate of attack is retarded as period of exposure increases. The scale forms continuous envelope, through which rate of diffusion of corroding atmospheres regulates attack upon underlying metal. (2) Straight line passing through origin. Weight increment is directly proportional to time, i.e., rate of attack remains constant as period of exposure increases. Scale is completely permeable, allowing free access of atmosphere to metal, itself playing neutral part. (3) Parabola whose axis coincides with weight axis of coördinates. Weight increment is proportional to square of time, i.e., rate of attack is accelerated as period of exposure increases. Scale is discontinuous and accelerates attack upon remaining metal in proportion to amount already present. Under certain conditions, particularly low relative humidity, rough surfaces show greater degree of tarnishing than smooth. In all instances differences in behaviour between hard metal and soft were exceedingly small, but wherever difference could be detected harder material was found to have undergone greater amount of change. Foregoing observations are general, being drawn from consideration of all materials investigated. Data on individual metals also given in original.—*R. E. Thompson.*

Second Report of the Relative Corrodibilities of Various Commercial Forms of Iron and Steel. J. N. Friend. Iron and Steel Institute (London) Carnegie Schol. Mem., **12**: 1-25, 1923. From Chem. Abst., **18**: 964, April 10, 1924. Effect of strain on rate of corrosion is slight, but samples employed in experiments were uniformly strained and galvanically insulated. Four types of tests were used: continuous immersion in tap water (1 year), 3 per cent sodium chloride (1 year), 0.5 per cent sulfuric acid (22 hours), and alternate wet and dry in tank which automatically filled and emptied every 2 hours. Different varieties of wrought and cast iron and carbon steels corrode in neutral media with remarkable uniformity, but in salt water wrought iron shows somewhat to advantage. In acid wrought iron is less resistant than steel, while cast iron is even more seriously attacked. Commercial pure iron is highly resistant to acid, quite satisfactorily resistant to salt water, and closely resembles other forms of iron in its resistance to tap water. With steels corrodibility in neutral media increases with carbon content up to eutectic point, followed by decrease, as previously found for acid attack; effect is not very great, however. It is most clearly seen in samples with low manganese content. Raising of manganese from 0.1 per cent to 0.5–0.9 per cent results is very slight increase in corrosion in neutral media up to 0.4–0.5 per cent manganese, and slight protection from that point up. There is, however, an enormously increased corrosion in dilute acid. These results validate conclusions previously reached. Copper in steel increases resistance to acid attack, but has little effect in neutral media. Chromium in steel increases resistance to attack in neutral media, but results with acids are variable. Nickel-chromium steel

usually resists dilute acid well. Addition of 0.4 per cent tungsten appears to be without effect on nickel-chromium steel. Field tests are in progress.—*R. E. Thompson.*

How Acid Mine Water Affects Corrosion-Resisting Metals. R. J. McKay. Chem. Met. Eng., 30: 228–9, 1924. From Chem. Absts., 18: 1107, April 20, 1924. M. reviews acid mine water corrosion tests (cf. C. A. 17: 2259) and shows corrosion of monel metal to be function of ferric iron as well as of acidity. Corrosion of monel metal by sulfuric acid in laboratory tests is increased 3- to 40-fold by addition of ferric iron.—*R. E. Thompson.*

The Mechanism of Metallic Corrosion (Copper). Guy D. Bengough and J. M. Stuart. World Power, 1: 25–34, 1924. From Chem. Abst., 18: 963, April 10, 1924. Results of Corrosion Research Committee of British Institute of Metals discussed at length. Highly purified copper when exposed to action of moist air becomes apparently covered with thin film, particularly in presence of sulfur compounds. If copper thus covered is immersed in distilled water, microscopic examination shows that the pronoucced local darkening is accompanied by thickening and swelling of scale, finally giving rise to minute blister. In course of time scale breaks down at such points and finally minute pits are formed. Local breakdown of scale appears to be accompanied by deposition of crystals of cuprite around pit. Area covered by crystals gradually increases until finally greater part of specimen becomes covered. Presence of pores in copper immersed in distilled water does not appear to be such an important cause of local action as in case of aluminum. Much more rapid action takes place on copper placed in sea water. One of initial products of corrosion is cuprous chloride, which is oxidized in time to cupric chloride and this attacks fresh copper to form more cuprous chloride. Action appears to be decidedly electrolytic. Scale on copper after immersion in sea water consists largely of crystalline cuprite, oxychloride, and, lowest layers, cuprous chloride. It also contains considerable quantities of cupric hydroxide, probably formed by reaction between cupric chloride and alkali produced by electrolysis at cathode (metal surrounding pit). Large part of scale produced on copper is crystalline in character and not glassy and transparent as in case of aluminium. Such scale is less uniform, less adherent and more porous than glassy scale. It allows slow general attack to proceed which results in roughening of metal. Electrochemical corrosion takes place in pure copper contrary to theory of others that presence of impurities is essential for forming of couple, scale being controlling factor. Colloids probably influence corrosion phenomena but their importance has probably been overemphasized, particularly as regards pitting.—*R. E. Thompson.*

Sterilized Distilled Water. Henry Kraemer. J. Am. Pharm. Assoc., 13: 35–8, 1924. From Chem. Abst., 18: 1365, May 10, 1924. U. S. P. method of preparing distilled water is faulty. Method should require presence of 1 per cent sulfuric acid in still and distillation should be conducted in apparatus entirely of glass. For sterile distilled water distillate should be collected in small bottles (100–500 cc.), containers plugged with cotton, wrapped in parch-

ment, and autoclaved for 20–30 minutes at 10–15 pounds pressure. Such water will keep indefinitely, but when once opened should be discarded.—*R. E. Thompson.*

Clarification of Effluents in the Lignite Industry. H. BAHR and K. KATHER. Braunkohle, **21**: 485–7, 1922; J. Soc. Chem. Ind., **42**: 877A. From Chem. Abst., **18**: 1378, May 10, 1924. Colloids in effluents from manufacture of briquets are negatively charged and can be precipitated and liquor thus clarified by addition of positively charged colloid such as magnesium hydroxide. Latter can be prepared in solution by addition of magnesium chloride and calcium hydroxide solutions. If concentration of these solutions and their amount and method of adding be suitably controlled, clarification can be carried out in 5 minutes. Thus liquor containing 2.5 grams of (dry) sludge per liter, requires addition of at least 6 cc. of 7.7 per cent magnesium chloride and 200 cc. of cold saturated lime water for rapid and complete clarification. Effluents containing phenols from carbonization process should not be added to liquor before clarification as phenols hinder precipitation. Water which has been used for coke quenching has opposite effect.—*R. E. Thompson.*

Gaseous Content of Ground Waters as an Aid to the Petroleum and Natural Gas Prospector. G. W. JONES, W. P. YANT and E. P. BUXTON. Bur. of Mines, Repts. of Investigations No. **2553**: 15 pp., 1923. From Chem. Abst., **18**: 1381, May 10, 1924. Simplified form of apparatus described as suitable for field determination, to nearest per cent, of carbon dioxide, oxygen, methane, ethane, and nitrogen in water. Data on analyses given showing that shallow spring waters do not contain methane and ethane but that these are found in deeper waters associated with occurrence of petroleum and natural gas.—*R. E. Thompson.*

Madison, Wis. Eng. News-Rec., **95**: 755–6, 1925. Sewage purification process employed consists of tank treatment and filtration, cost of disposal being $18.89 per million gallons, of which $5.34 is for treatment. Hardness of water supplied, derived from wells, is 300 p.p.m. No treatment is employed. Water charges average 6 cents per 100 cubic feet. Services are 100 per cent metered and per capita consumption is 100 gallons per day.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Railway Water Supply and Treatment. R. C. BARDWELL. Eng. News-Rec., **95**: 807, 1925. Of 350 billion gallons of water used annually for steam production on American railways, approximately 50 billion gallons are treated, average cost being 4 cents per 1000 gallons. Study by Committee of American Railway Engineering Association indicated that 13 cents was conservative estimate of cost—fuel consumption, repairs, and time lost—due to each pound of incrusting materials entering boilers. Least expensive method of treatment is by addition of soda ash in roadside tanks, but resulting water gives rise to acute foaming unless concentration in boiler water is kept low by frequent blowing off. Zeolite softening has not been widely employed for

railway purposes owing to high cost and excessive alkalinity of treated water and resulting foaming. Lime-soda method, carried out in roadside settling tanks, is the standard and complete method of softening.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Finding the "Critical Depth" in Hydraulic Jump Computations. FRANK S. BAILEY. Eng. News-Rec., **95**: 810–1, 1925. Diagram given for quickly determining critical depth of water flowing in open channels, namely, that point where energy head, i.e., depth plus velocity head, is minimum for given rate of flow.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Pipe Steel Shipped Flat then Rolled and Welded. C. A. P. DUFFIE. Eng. News-Rec., **95**: 872–3, 1925. Illustrated description of construction of water pipe line (16,000 feet of 30-inch and 26,000 feet of 24-inch), steel for which was shipped flat and fabricated by oxywelding. Each length of pipe was tested prior to placing and only 3 joints were returned to shop for re-welding. After testing, pipe was passed successively throuh hot alkali to remove grease, hot dilute H_2SO_4 to clean off scale, alkaline neutralizing bath, and hot rinse water. Pipe was then dried by means of gas flames playing on outside, capped at each end, dipped in asphaltum and rolled in grit.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Charleston, S. C. Eng. News-Rec., **95**: 909–11, 1925. Sewage of city drains to 9 pumping stations and is pumped into 2 rivers through series of outfalls. Water supply, which is filtered, is derived from Goose Creek. Average daily consumption is approximately 7 m.g.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Large Additional Water Supply Recommended for Boston Metropolitan District and Worcester. Eng. News-Rec., **95**: 944–6. 1925. Recommendations of Metropolitan Investigating Commission include additional supply of 180 m.g.d. to be provided in 3 installments during next 30 years at estimated cost of $85,500,000, and purification of present and additional supplies by filtration. Twenty cities and towns are at present supplied from system. Approximately 95 per cent of all services are metered and the per capita consumpton is 95 gallons per day.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Portland, Maine. Eng. News-Rec., **95**: 955–6, 1925. Water is supplied by Portland Water District from Sebago Lake, 16 miles distant. Chlorination is only treatment employed.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Salt Water in Fire Mains Speeds Corrosion. Eng. News-Rec., **95**: 956, 1925. During last 2 years, since salt water has been employed for fire extinguishing in San Francisco, leakage from high pressure system has increased from 125,000 to 225,000 gallons daily. This is ascribed to deterioration of pipes as result of accelerated corrosion and electrolysis due to salt water, and an appropriation has recently been made to provide fresh water for this purpose.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Kentucky Health Board Rates Water Supplies. F. C. DUGAN. Eng. News-Rec., **95**: 957, 1925. Based on character of raw water, methods of treatment, operation of plant, and analyses of water supplied, 30 of 91 water systems inspected by State Board of Health in Kentucky are rated as good, 28 as doubtful, 29 as bad, and 4 no rating but probably good. List of cities inspected with their classification, is given.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Ready Means of Estimating Quantities of Cement Materials. E. EARL GLASS. Eng. News-Rec., **95**: 965–6, 1925. Method of estimating described based on assumption that cement, coarse and fine aggregate all weigh approximately 100 pounds per cubic foot and that average weight of plain concrete is 145 pounds per cubic foot. Method provides means of determining approximate weight of materials required for the odd proportions encountered when mix is controlled by screening tests and fineness modulus. Accuracy is equivalent to that of methods used heretofore.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Electrically Welded Water Pipe: Tacoma's Experience. W. A. KUNIGK. Eng. News-Rec., **95**: 968, 1925. Experience in Tacoma, Wash., with electrically welded 30- to 60- inch steel pipe is reviewed and data on difficulties encountered given. Test bars cut from a number of sections of finished pipe, all of which were hand-welded, developed joint efficiencies of 80–100 per cent, all breaks occurring $\frac{1}{8}$ to $\frac{1}{2}$ inch from weld, except in 1 instance.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Engineering Year in Review and Prospect. Eng. News-Rec., **96**: 49–57, 1926. **Water Works.** Ibid. 54. In the U. S. there are approximately 10,000 and in Canada about 750 communities served by public water supplies. Chicago and Milwaukee are now the only cities on Great Lakes which have not filtration plants in use or under construction. **Sewage.** Ibid. 54–5. Imhoff tank treatment, with sprinkling filters when further treatment is required, is the principal method of sewage purification employed in U. S.; use of fine screening, either alone, or with other processes, is extending.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

St. Louis Water Supply. Eng. News-Rec., **96**: 84, 1926. Status of $12,000,000 water supply project is outlined. Plant, which will treat Missouri River water, will probably be in commission early in 1928.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Kansas City, Mo., Water Works. Eng. News-Rec., **96**: 84, 1926. Progress in construction of filtration plant of Kansas City is reviewed briefly.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Catskill Aqueduct System. Eng. News-Rec., **96**: 85, 1926. Gilboa dam, now nearly complete, will form a 20 billion-gallon reservoir and divert water of Schoharie Creek through the 600-m.g.d. Shandaken tunnel to Esopus Creek and thus into Ashokan reservoir, from which 156-mile Catskill aqueduct leads

to N. Y. City. The Gilboa dam will virtually complete Catskill aqueduct system as originally planned.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Sounding Bottle for Taking Samples of Water in Reservoirs. CARL F. KLAPP. Eng. News-Rec., **95**: 1083, 1925. Device for sampling water at varying depths described and illustrated.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Philippines Have Many Water Works Systems. Eng. News-Rec., **95**: 1029, 1925. Including Manila metropolitan water system there were 123 water works in use in Philippine Islands at close of 1924, 35 in course of construction and 101 under consideration. Systems in use serve in excess of 378,000 people, those under construction will serve 115,000, and projects under consideration would serve 378,400.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Portsmouth, Va. Eng. News-Rec., **95**: 879–80, 1925. Sewerage system to serve approximately one-third of city's area is under construction. Sewage will be pumped into Elizabeth River just beyond harbor bulkhead. Water supply of city, derived from Lake Kilby, is purified by filtration.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Half of Lowell Service Pipes Changed Within 52 Years. ROBERT J. THOMAS. Eng. News-Rec., **95**: 1041, 1925. Almost half of 15,695 services installed since 1873, first year after initial operation of water works, have been changed due to (1) corrosive action of original infiltrated and river supplies on wrought iron pipe; (2) action of later driven-well supplies on Pb and Pb-lined wrought Fe pipe, which caused Pb poisoning; and (3) leakage from Sn-lined wrought Fe pipe used in place of Pb-lined service. Cement-lined, tar-coated and rubber-treated pipes have been experimented with. Pb now predominates. Galvanized Fe has been employed during past 10 years, but little confidence is placed in its durability. If CO_2 were removed from well supplies, Pb pipe would be as effective as brass. Considerable difficulty was formerly experienced due to incrustation of pipe of all materials, including Pb, with Fe and crenothrix, but this condition has been remedied by installation of Fe removal plant.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Everett, Wash. Eng. News-Rec., **95**: 841–2, 1925. Main source of present water supply is Sultan River. Peak demand is 8.6 m.g.d., or 270 gallons per capita per day. Supplementary supplies are under consideration. During past 2 years oxyacetylene welded steel pipe has been used exclusively and found highly satisfactory. As much as 800 feet of 20-inch pipe in 30-foot lengths has been welded on street surface and lowered into trench in one piece. It has not yet been found necessary to repair a welded joint, including the experimental welds made 5 years ago. Joints are covered with tar paint internally and externally after welding.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

How Laboratory Supervision Saves Omaha, Neb., $9000 per Year. KENNETH C. ARMSTRONG. Eng. News-Rec., **96**: 119, 1926. The amount of chemicals

required to effect coagulation of water at Omaha is determined by laboratory trials in series of jars, and it is estimated that employment of this method will have effected saving of $9000 during 1925 as compared with previous 6 years, notwithstanding fact that raw water was more turbid than in 1924. It has been found that addition of small dose of $FeSO_4$ ($\frac{1}{4}$ grain per gallon) enables alum dosage to be reduced from $2\frac{1}{4}$ to 1 grain per gallon. If larger amounts of $FeSO_4$ are employed, more lime is required, and it is therefore more economical to increase the alum when higher dosage of coagulant is needed. Laboratory experiments indicated that $FeSO_4$ should be added first, but in practice it has been found satisfactory to mix the alum and $FeSO_4$ in solution tanks and add the mixed solution to the water to which lime has been previously added.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Field Tests of Concrete. Cont. Rec., 39: 1007, 1925. Description and discussion of method of making slump test of concrete and of preparing cylindrical specimens for compression tests.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Water Filtration and Softening as Applied to Clay Products Plants. H. M. Marsh and W. J. McLelland. Cont. Rec., 39: 1161–3, 1925. Description of water purification plant of Don Valley Brick Works, which consists of settling and coagulation basin, mechanical pressure filter, and zeolite water softener.—*R. E. Thompson.* (*Courtesy Chem. Absts.*)

Progress in the Purification of Water Supplies. Norman J. Howard. Cont. Rec., 39: 52, 133–8, 1925. Extensive review of progress in water purification during 1925. Employment of double filtration in dealing with heavily polluted and turbid waters is extending. A solution composed of alum, Na_2CO_3, and NaOCl, concentration of latter being varied in proportion to Cl-consuming power of water, is being employed in Ontario in preparation of certain acid waters for filtration. Prechlorination and $CuSO_4$ treatment of a slow sand filter at Toronto, Ont., recently, in effort to increase length of run between scrapings in early spring when microscopic content of raw water was high, proved unsuccessful. Superchlorination and dechlorination has recently been experimented with at Toronto, Ont., as a means of eliminating medicinal taste which occasionally occurs following chlorination, and this process will be tried on large scale in near future.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Developments in Water Softening. W. J. McLelland. Cont. Rec., 39: 52, 138–9, 163, 1925. Discussion of hardness in water, its effect on boilers and in textile industry, and its removal by Clarke or lime-soda process or by base exchange. Scale $\frac{1}{8\,0}$ inch in thickness in boilers causes fuel loss of 1–10 per cent and $\frac{1}{1\,6}$ inch, 2–20 per cent, depending on composition of deposit.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Powdered Coal for the Des Moines Water Works Boilers. Eng. News-Rec., 96: 107, 1926. What is claimed to be first powdered coal boiler installation (designed by G. A. Conrath) for water works pumping station is described

briefly. Steam plant consists of 4 boilers, and total rated capacity is 1292 h.p. Only one boiler has been converted for use of powdered coal, but pulveriser is of capacity sufficient for whole plant. Enlarged furnace is 18 feet deep from water tubes to bottom of furnace, providing 0.5 cubic foot of furnace volume per square foot of steam-making surface. Furnace temperature is 3000°F., compared with 1800–2000° formerly. It is estimated that annual saving by new equipment, which cost $2500, including enlargement of furnace, will be $7500.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Springfield Slow Sand Filters Doubled. Eng. News-Rec., **96**: 19, 1926. Water filtration plant of Springfield, Mass., has been enlarged to a little more than double original capacity—rated at 15 and operated easily at 12 m.g.d. Water is coagulated during periods when color of Little River water is noticeable and delivered into open sedimentation basin, from which, after 24 hours retention, it passes into larger basin, and thence to filters.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

St. Paul's Water Consumption and Costs in 1924. J. W. Kelsey. Eng. New-Rec., **95**: 1041, 1925. Daily per capita consumption during 1924 was 76.9 gallons. As ground water is easily obtained, city supplies only approximately 60 per cent of total water consumed. Cost of maintenance during year was equivalent to $57.37 per million gallons, and total cost, including interest and sinking fund, $103.35. Services are 100 per cent metered.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

$101,028,000 Needed for Sewerage and Treatment at Detroit. Eng. News-Rec., **96**: 112–3, 1926. It has been recommended that within next 7 years, $61,428,000 be expended on sewerage extensions and $39,600,000 for intercepting sewers, pumping stations, and a single treatment plant. The purification works proposed consist of bar screens, grit chambers, skimming-detritus plant, Imhoff tank sedimentation-sludge digestion plant and suitable equipment for disinfection of effluent, which will be discharged into Detroit River. In addition to sewage of Detroit and other municipalities, industrial wastes, including oil and grease, are also discharged into river, resulting in serious pollution of city water supply and of neighboring bathing beaches. Typhoid fever has been traced to latter, and their use has been prohibited by Local Board of Health.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Some Specific Factors Responsible for Pollution Affecting Analysis of Water Supplies. H. A. Whittaker. Cont. Rec., **39**: 1025–6, 1925. Tabulation of factors influencing sanitary quality of water supplies.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Concrete Improved by the Use of Diatomaceous Earth. C. N. Conner. Eng. News-Rec., **95**: 995–6, 1925. Experiments carried out by N. Carolina State Highway Commission indicate that addition of diatomaceous earth increases strength and promotes workability of concrete. Diatomaceous earth used was specially prepared material known commercially as celite, and was of

the plankton marine type. The average increase in compressive strength of concrete containing various percentages of celite, as compared with plain concrete, was 3 per cent at 28-day age and 8 per cent at 1 year. Increased workability when celite is employed, permits use of drier consistencies in field concrete. Field investigations with celite indicated increase of approximately 10 per cent in strength of specimens of average age of 5 months. From physical tests there is evidence of combination between free lime of cement and amorphous SiO_2. Examinations of cores drilled from plain concrete pavements show that concrete at edges varies more in quality than that in center, although average strength might be equal, probably due to greater amount of handling of edge concrete. Comparison of pavements under study shows that mean variation in plain edge concrete is about 60 per cent greater than in that containing celite. Records of projects employing celite show increased yield of concrete and lower operating costs. Specifications for diatomaceous earth for this purpose are included. Specifications call for 2 per cent in 1:1½:3 concrete; 3 per cent in 1:2:4 concrete; 4 per cent in 1:2½:5 concrete (gravel coarse aggregate); and 5 per cent in 1:2½:5 concrete (crushed stone or slag coarse aggregate). Use of over-sanded mixtures has become popular as means of securing workability. These mixtures produce workability to certain extent, but sand lacks in unit effectiveness and sacrifices density and strength. Uniformity of concrete does not appear to be increased by use of over-sanded mixtures.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Not so Favorable to Admixtures in Concrete. T. P. Watson. Eng. News-Rec., **95**: 1084 (1925). Statements of Conner (cf. preceding abstracts) are at variance with experience of Watson, which has been that compressive strength of concrete is dependent on cement-water ratio of mix, irrespective of proportions, with or without admixtures. Use of latter necessitated in all cases additional water to obtain same workability, which reduced compressive strength accordingly. Careful proportioning of concrete mixtures with graded aggregates will ensure satisfactory workability. If arbitrary proportions are specified and additional workability is required, it will usually be more economically accomplished by employing additional cement.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Concrete Admixtures. G. W. Hutchinson. Eng. News-Rec., **96**: 129–30, 1926. Criticism of Watson's discussion (cf. previous abstract).—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

More on Concrete Admixtures. G. M. Williams. Eng. News-Rec., **96**: 129, 1926. Discussion of article of Conner (cf. previous abstracts), with special reference to "oversanded" mixtures, which are shown to be superior under certain conditions, fineness of sand, expressed as surface area, being controlling factor. Sands having surface area of less than 700 square inches per 100 gallons permitted use of 1.0 sand-gravel ratio, while sand approaching 1100 square inches gave best results with 0.5 ratio. In the case of a Saskatchewan sand of surface area of 350–500 square inch ratio of 1.0–1.5 gave best quality concrete, which was stronger and more easily placed than mixtures

conforming to 2:4 and 3:6 ratios. These "oversanded" concretes require a greater quantity of mixing water and are less dense but more watertight or impermeable.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Sterilization by "Ferrochlor" of Water of Rivers Used as City Supply. NOËL ADAM. Rev. universelle des Mines, February 15, 1924; Le Genie Civil, 84: 387–388, 1924. Hypochlorites and ferric chloride are used. Material added therefore contains hypochlorous acid, ferric oxide, and a ferrate, and is energetic bactericide. Process has been used for some years at Middelkerk, Belgium, and at Letoure, France. Experiments made at Paris indicate that dose at latter would not be more than 4 or 5 grams hypochlorite per cubic meter.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Construction of Galleries Under Pressure in Impermeable or Fissured Terrains. Schweiz. Bauzeitung, October 31, 1925; Le Genie Civil, 87: 539–540, 1925.—*Jack J. Hinman, Jr.*

Water Supplies of the Communes in the Vicinity of Paris. LE COUPPEY DE LA FORÊT. La tech. sanit., 20: 247–248, 1925. Water of the Compagnie des Eaux de la Banlieu is taken from Seine at Suresnes, put through pre-filters and slow sand filters, and chlorinated.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Problem of Supplying Potable Water for the Paris District. FERNAND LAURENT. La tech. sanit., 20: 245–7, 1925. Consumption in 1913 was about 280,000 cubic meters per day. Recently it has exceeded 600,000 cubic meters in hot weather. Additional sources of water supply are needed to care for needs of city.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Sinking Artesian Wells by American Methods. H. VIGNERON, La tech. sanit., Rotary drilling by Layne method, using mixture of water and clay. Earth is consolidated by injection of clay for several meters beyond drill hole and openings through pervious strata above desired aquafer are thus closed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Supply for Northern New Jersey. Pub. Works, 57: 13–16, 1926. Chimney Rock project recommended by Northern Jersey District Water Supply Commission for supplying this section with water is described. Chimney Rock site was chosen because of its many natural advantages. A 66,000 million gallon reservoir could be built at this site with connections to 160 square miles of drainage area. Cost of reservoir and connections to drainage area with aqueducts to center of Six Counties is estimated at $46,000,000. This would yield supply of 150 million gallons per day. Analyses showed water to be of excellent quality so that filtration would not be needed during early years. Supply to Chimney Rock reservoir could later be developed to yield a total of 750 million gallons per day which would satisfy estimated requirement of District in 1970.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Improving Boston Metropolitan Water Supply. Pub. Works, **57**: 17–18, 1926. Report of Metropolitan Water Supply Commission is reviewed. Filter plant is recommended to treat the 26 million gallon per day South Sudbury supply. To supply immediate needs, construction of dam on Ware River, thereby creating reservoir which would supply 45 million gallons per day, is recommended. This development would cost $14,000,000. Three projects to be developed later which would add 47, 80, and 50 million gallons per day to the supply at costs of 8.5, 19, and 12 million dollars respectively are also recommended.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Tampa's New Water Works. Pub. Works, **57**: 1–6, 1926. Complete description of new water works is given. Old supply was obtained from twenty ten-inch wells from 165 to 328 feet deep with total capacity of 6 million gallons per day. This supply had become unsatisfactory on account of high salinity; but it will be maintained as a reserve. New supply is taken from Hillsboro river. River water has color range from 26 to 200 p.p.m. and hardness range from 30 to 200 p.p.m. Period of maximum hardness coincides with that of minimum color. Low-lift pumps take water from intake wells to first mixing chamber whence it flows by gravity through entire plant to filtered water reservoir. It is then pumped through 3 miles of 30-inch force main to distribution system and to three elevated tanks each of 500,000 gallons capacity. Pumping and purification plants are designed to handle 12 million gallons per day with provision for 25 per cent overload. Lime will be added in first mixing chamber for softening. Sulphur dioxide will be added with alum for decolorizing.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst*)

Nine Charts for Flow of Water in Channels. George Higgins. Eng. and Cont., **64**: 607–13, 1925. Diagrams to facilitate hydraulic computations are presented.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Combined Reservoir and Tennis Court. Waldo E. Smith. Eng. and Cont., **64**: 1254–55, 1925. A 2 million gallon ring tension type reinforced concrete reservoir for Ponca City, Oklahoma is described. Reservoir is 160 feet in diameter with inside depth of 15 feet and is provided with 10 by 10 by 12 feet sand trap where incoming line enters. Floor is from 6.5 to 11 inches thick; wall is uniformly 14 inches thick; and mushroom type reinforced concrete columns 16 inches in diameter are placed 20 feet apart each way. The roof is 6-inch reinforced slab and will provide two tennis courts.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Municipal Water Softening. W. C. Hirn and E. F. Eldridge. Eng. and Cont., **64**: 1281–88, 1925. The first small water softening plant in U. S. was installed at Oberlin, Ohio, in 1904. By 1915 there were 7 important plants in U. S., and since then 19 additional plants have been put into operation. Water softening was developed rapidly by the railroads, first plant being installed in 1906; by 1914, 348 plants were being used by lines of middle west. Chemistry of water softening is briefly discussed and two diagrams for calculating hardness and amounts of lime and soda ash required are presented.

Cost of a water of average hardness in State of Michigan to city of 10,000 is calculated at $2.07 per capita per year. It is shown that cistern supply of soft water for such a city would cost $4.20 per capita per year. Cost of water softening for same city is calculated to be about $1.02 per capita annually. Public's objection to softened water on score of palatability was shown to be groundless by experiments at Lansing.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

NEW BOOKS

Drainage and Flood-Control Engineering. GEO. W. PICKELS. New York and London: McGraw-Hill Book Co. Inc. Cloth: 6 by 9 inches; pp. 450. $4. Reviewed in Eng. News-Rec. 95: 1002-3, December 17, 1925.—*R. E. Thompson.*

The Economics of Public Utilities. L. R. NASH. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6 by 9 inches; pp. 430. $4. Reviewed in Eng. News-Rec. 95: 1004, December 17, 1925, and Munic. Eng. 76: 723, December 24. 1925.—*R. E. Thompson.*

The Chemistry of Power Plant. W. M. MILES. Ernest Benn, Ltd. pp. 144. 6s., by post 6s. 4d. Reviewed in Munic. Eng., 76: 722, December 24, 1925.—*R. E. Thompson.*

Technical Plumbing and Sanitary Science. S. BARLOW BENNETT. B. T. Batsford, Ltd. 4th. Ed. pp. 285. 9s. 6d., by post 10s. Reviewed in Munic, Eng., 76: 676, December 10, 1925.—*R. E. Thompson.*

Introduction à l'étude des colloides. L'état colloidal et ses applications. W. KOPACZEWSKI. 16mo (18.5 x 12 cm.) 220 pages, 38 figs., Gauthier-Villars et Cie., publishers, Paris. Noted in Le Genie Civil, 87,475 1925.—*Jack J. Hinman, Jr.*

Théorie général et formulaire pratique du ciment armé. CHARLES AMAR, 8vo, 179 pages, many figs and plates. Gauthier-Villars et Cie., publishers, Paris. Noted in Le Genie Civil, 87: 524, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Turbines hydrauliques. A. RATEAU, D. EYDOUX and M. GARILL, 8vo, pp. 692, 178 figs., J. B. Baillière et fils, publishers, Paris. Noted in Le Genie Civil, 87: 524, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)